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**Cui et al.**

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(54) **SYSTEMS AND METHODS FOR EFFICIENT BOX PACKING AND VISUALIZATION**

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(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 220 days.

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This patent is subject to a terminal disclaimer.

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*Primary Examiner* — Michael Jared Walker

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(74) *Attorney, Agent, or Firm* — Finnegan, Henderson, Farabow, Garrett & Dunner, LLP

(65) **Prior Publication Data**

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(57) **ABSTRACT**

**Related U.S. Application Data**

Systems and methods are provided for efficient box packing and visualization. One method comprises receiving, from a remote system, an order comprising at least one item; searching at least one data store to determine dimensions associated with the at least one item; and modifying dimensions of at least one largest item of the order using a factor. The method may further comprise selecting a data structure representing a first package, the data structure comprising a size of the first package; iteratively simulating packing the items into the first package based on the modified dimensions, until all items are packed in the selected package; and generating at least one set of instructions for packing the items into the selected package. The method may further comprise sending the generated instructions to a second system for display, the instructions including at least one item identifier and one package identifier.

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(51) **Int. Cl.**

**G06Q 50/28** (2012.01)

**G06F 30/20** (2020.01)

(52) **U.S. Cl.**

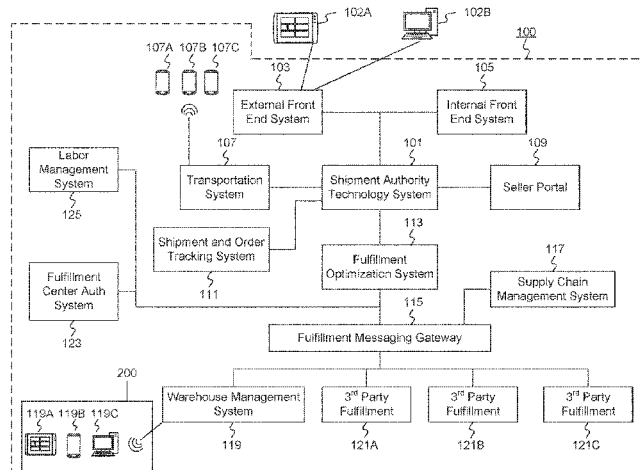
CPC ..... **G06Q 50/28** (2013.01); **G06F 30/20** (2020.01)

(58) **Field of Classification Search**

CPC ..... G06Q 50/28; G06Q 10/06312; G06Q 10/06316; G06Q 10/0832; G06F 30/20; G06F 30/17; G06F 2113/20

See application file for complete search history.

**20 Claims, 13 Drawing Sheets**



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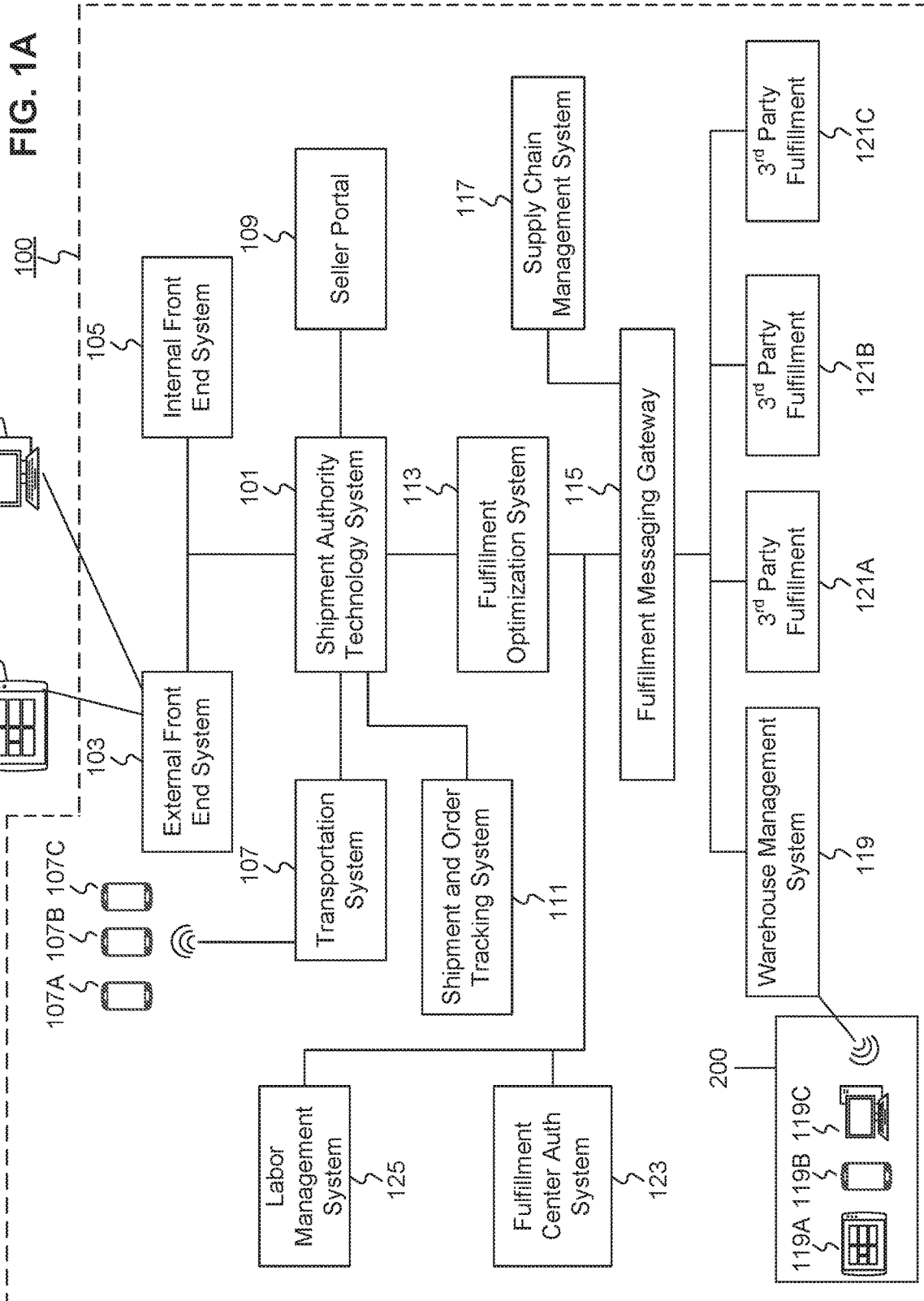
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login Sign Up Service center

Category Cheese ? 

My Orders Shopping Cart

all 'Cheese' (65,586) Gift Cards

**filter**

Fast Delivery  
 Imported Product

**category**  
All  
Food  
Silverware  
Kitchen utensils  
Home electronics digital  
Household goods  
View more

**brands**  
Local Milk  
Daily dairy  
Cattle and trees  
View more

**scope**  
All stars  
4 or more  
3 or more  
2 or more  
1 or more

**65,586 results for 'Cheese'**  
Related searches: [Sliced cheese](#) [baby cheese](#) [cheddar cheese](#) [string cheese](#) [butter](#) [pizza cheese](#) [cream cheese](#) [cheese stick](#) [cubed cheese](#) [parmesan cheese](#)

6 per page


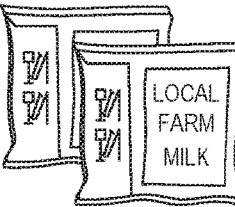

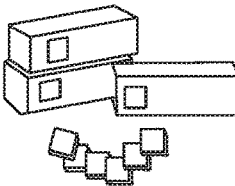


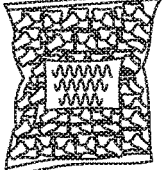
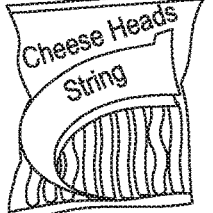
 <p>FREE Shipping  Sliced cheese, 18g,  100 pieces  (88 won per 10 g)  Morning (Thursday)</p> <p>(1294)</p>	 <p>Mozzarella cheese,  1kg, 2 pieces    (103 won per 10 g)  Tomorrow (Wed)</p> <p>(285)</p>	 <p>100 grams of cheddar  sliced cheese,  18 grams, 100 pieces  (73 won per 10 g)  Morning (Thursday)</p> <p>(862)</p>
 <p>Grated Parmesan  Cheese, 85g, 1 piece    (389 won per 10g)  Tomorrow (Wed)</p> <p>(839)</p>	 <p>Mozzarella cheese,  1 kg, 1  (85 won per 10g)  Morning (Thursday)</p> <p>(379)</p>	 <p>FREE Shipping  1.36 kg of string  cheese  Morning (Thursday)</p> <p>(337)</p>

FIG. 1B


Favorites Application
login Sign Up Service center

My Account Shopping Cart

Shipments Fast Shipments Christmas Gold deals Regular delivery Events / Coupons Planned Exhibition

Gift Cards

Home > Food > Daily products / ice cream > Cheese > Fresh cheese > Mozzarella



**mozzarella cheese**  
285 Reviews 20,000 won

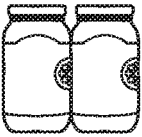
**FREE Shipping**  
**Tomorrow (Wed) 11/28 Arrival Guarantee**

Weight per piece x Quantity : **1kg x 2 pieces**


1
Add to cart
Buy now

- Country of origin: See product description
- Shelf Life: 2019-11-04
- Total quantity: 2
- Cheese form: crushed (powder)
- Item Number: 23532 - 3432551


**Products purchased by other customers**




Rosé spaghetti sauce, 600g, 2...  
**6,500 won**  
(54 won per 10g)  
(3,721)




Chunky Tomato Pasta...  
**3,800 won**  
(86 won per 10g)  
(545)




Grated Parmesan cheese,  
**6,460 won**  
(285 won per 10g)  
(1,330)



Bacon and Mushroom Cream Pasta Sauce  
**4,870 won**  
(108 won per 10g)  
(3,193)



Chilli sauce, 295ml, 1  
**2,370 won**  
(80 won per 10ml)  
(2,552)



Hot sauce,  
**2,340 won**  
(66 won per 10ml)  
(245)

Product Details
Reviews (285)
Contact Us
Shipping & Returns

**Required notation information**

Type of food	Natural cheese / frozen products	Producers and Locations	Cheese Corp. / Republic of Korea
Date of manufacture, shelf life or quality maintenance	Shelf Life: Products manufactured on or after November 04, 2019 : Manufactured goods after May 19, 2018	Capacity (weight), quantity by packing unit	1kg, 2 pieces
Ingredients and	Content reference	nutrient	None



FIG. 1C

11/28/2018 Shopping Cart

**General Purchasing (1)**      **Periodic Delivery (0)**

Select All      Product Information      Item Amount      shipping fee

**Rocket shipping products free shipping**

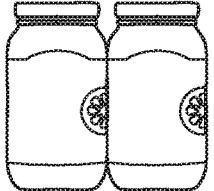

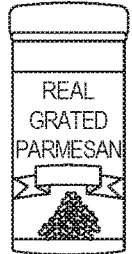

<input checked="" type="checkbox"/>		Mozzarella cheese, 1kg, 2 pieces Tomorrow (Thursday) 11/29 Arrival guarantee (order before 12 pm)		20,510 won	<input type="text" value="1"/>	free
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Even if you add other rocket shipping products, free shipping available      shipping Free      Order amount \$20.00

Select All (1/1)                 

**Customers who bought this product also purchased**

			
Rosé spaghetti sauce, 600g, 2 pieces <b>6,500 won</b> (54 won per 10g)	Napoli Chunky Tomato Pasta Sauce, <b>3,800 won</b> (86 won per 10g)	Grated Parmesan cheese, <b>6,460 won</b> (285 won per 10g)	Bacon and Mushroom Cream Pasta Sauce, <b>4,870 won</b> (108 won per 10g)


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FIG. 1D

**Order / Payment** Shopping Cart > **Order Payment** > Order Completion

**Buyer Information**  
name  
e-mail  
Mobile Phone Number 0123456789

**Recipient information**   
name   
Shipping address  
Contact  
Delivery Request Front door

**Shipping 1 out of 1**  
**Tomorrow (Thursday) 11/29 arrival guarantee**  
Mozzarella cheese, 1kg, 2 pieces 1 quantity / free shipping 

**Billing Information**  
Total product price \$20.00  
discount coupon 0 No applicable discount coupons available.  
shipping fee 0  
MyCash 0  
Total payment amount \$20.00 – MyCash to be credited \$0.40

Payment Method  Rocket Transfer   Rocket credit/check card  Credit/Check Card  
 Cellphone  Bank transfer (virtual account)

Select bank

I agree to use future payments with the selected payment method (Selection)

**Cash receipts**  
 Apply for cash receipt

\*A cash receipt will be issued for the amount of cash deposited at the time of settlement of cash.

I have confirmed the order above and agree to the payment.

FIG. 1E

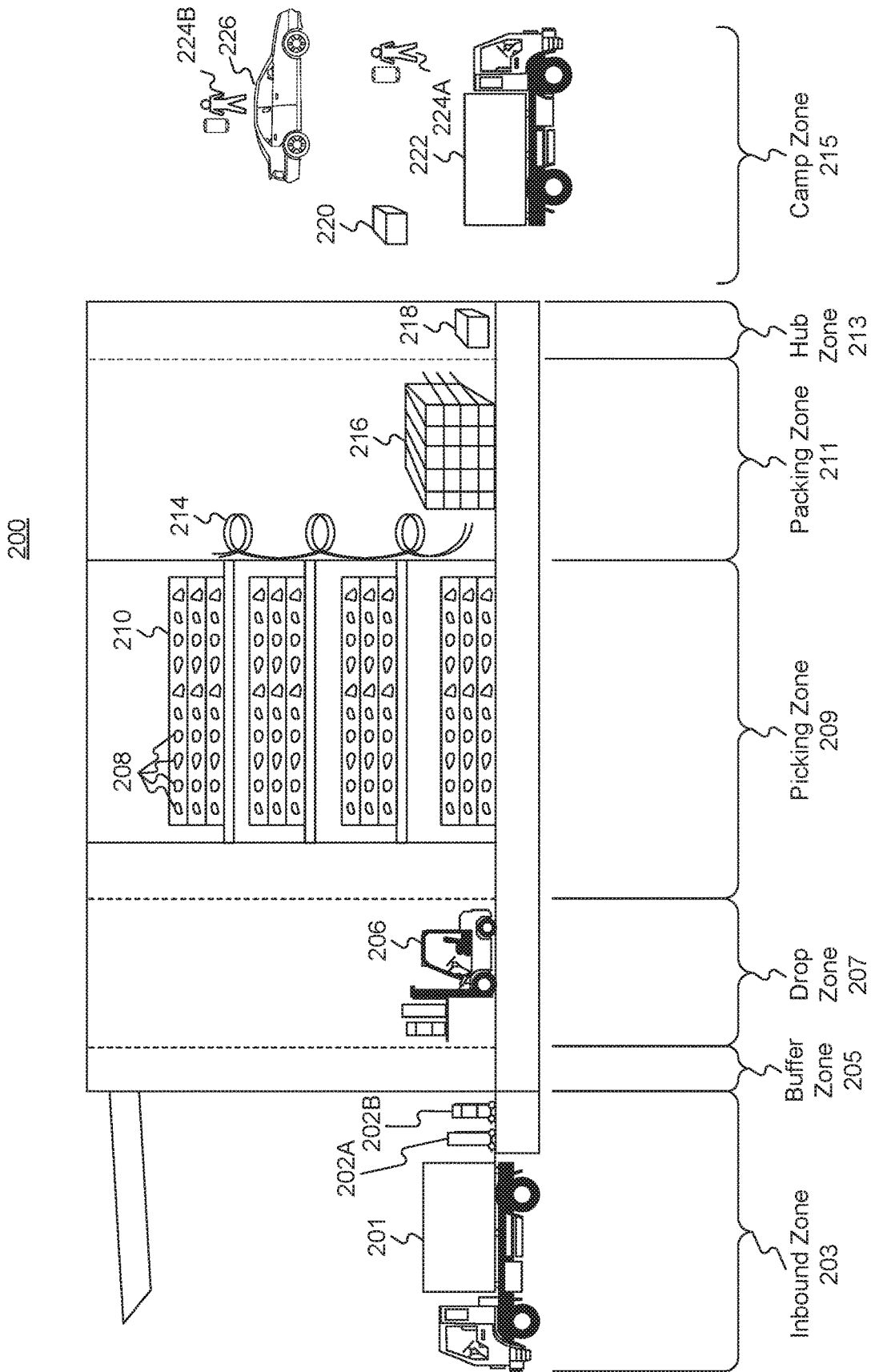


FIG. 2

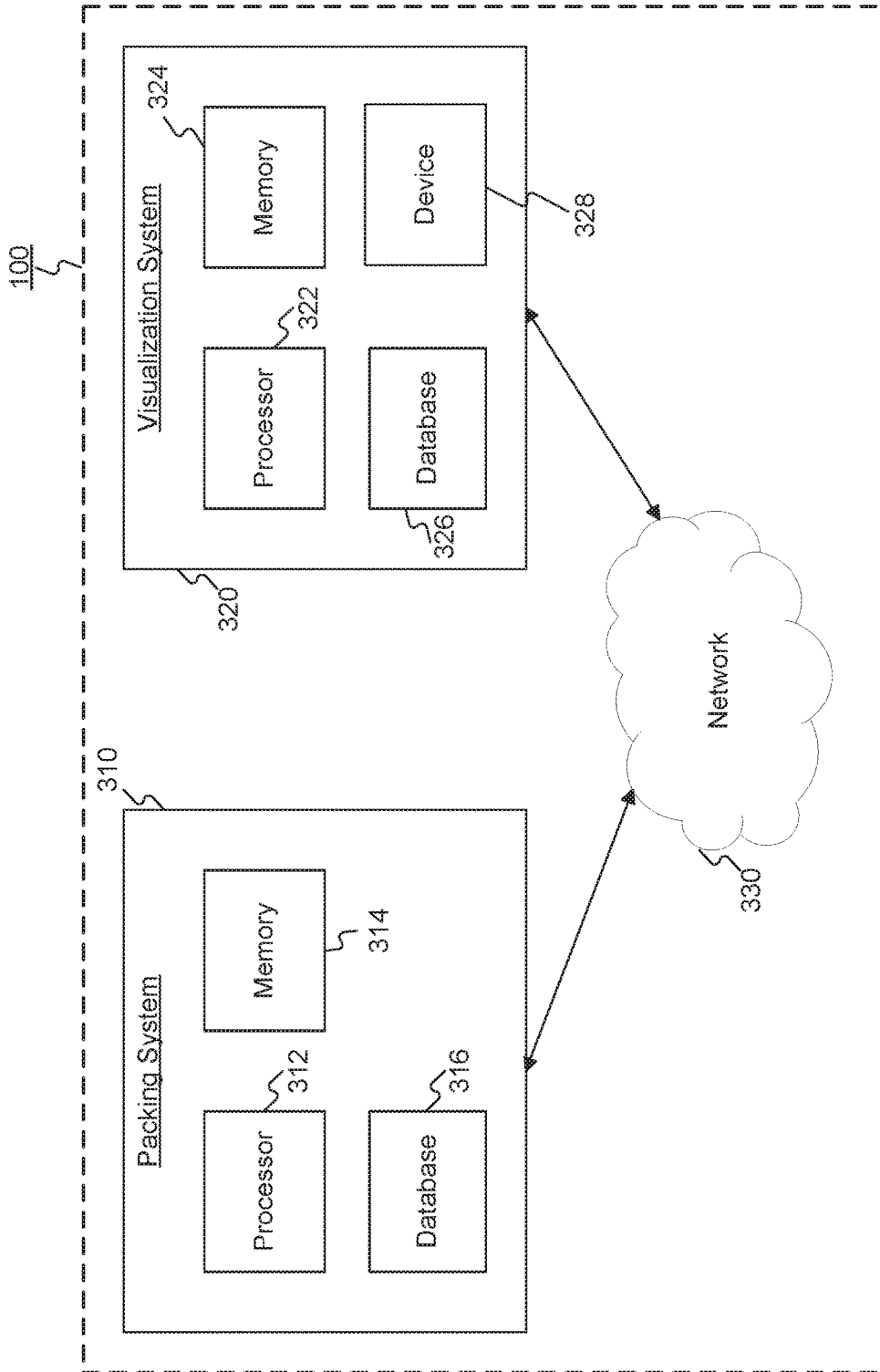


FIG. 3

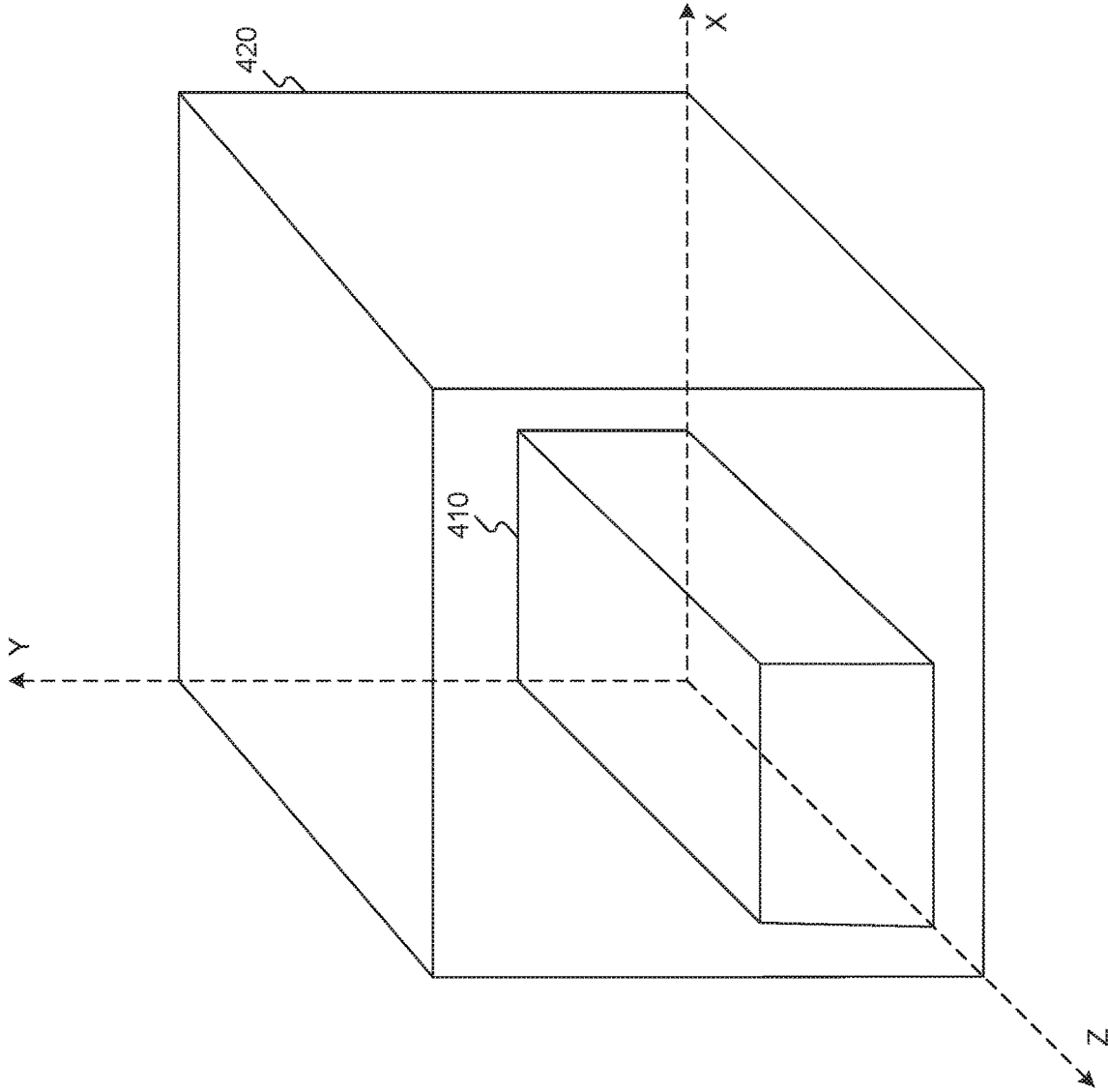


FIG. 4

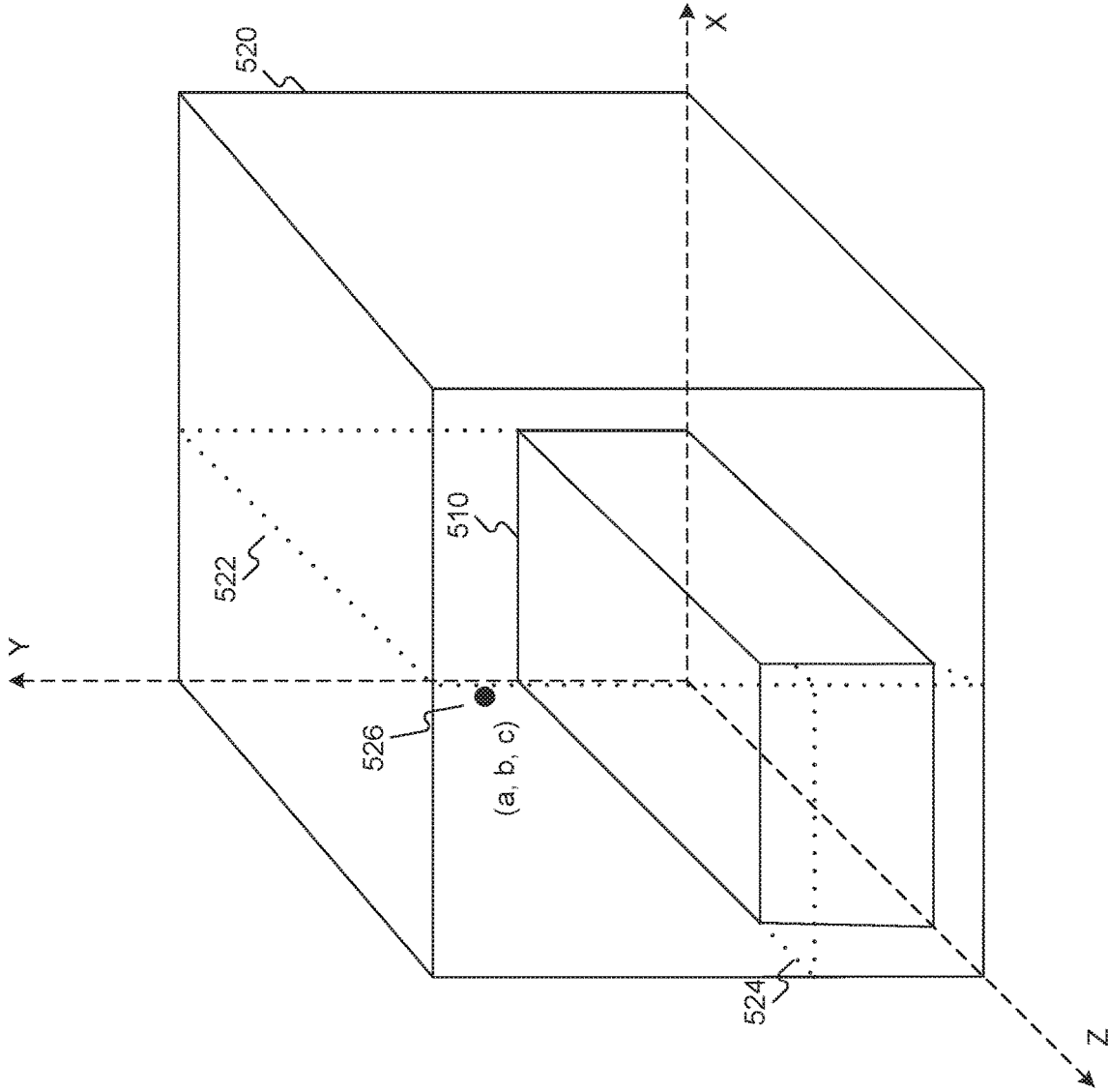


FIG. 5

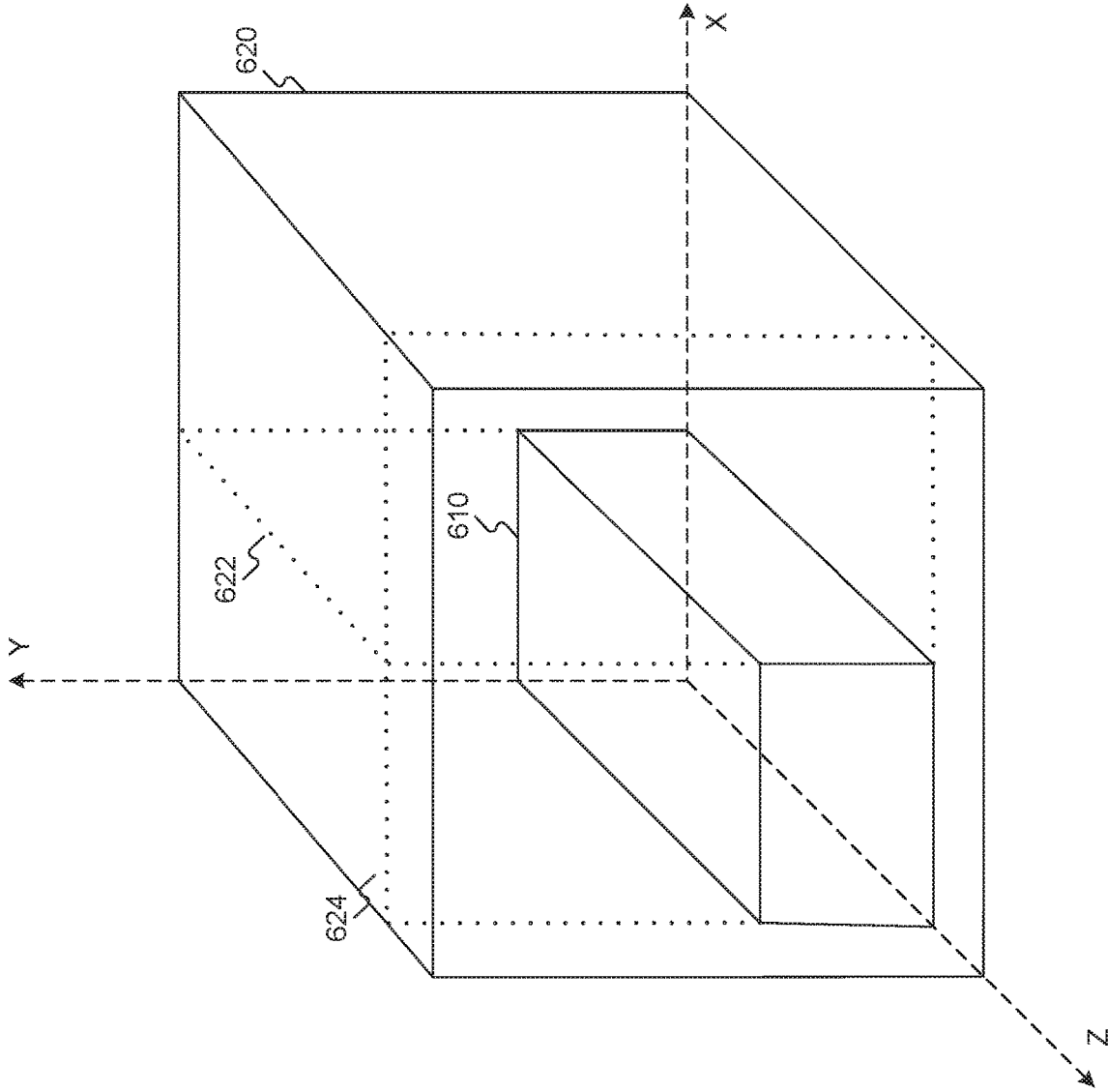


FIG. 6

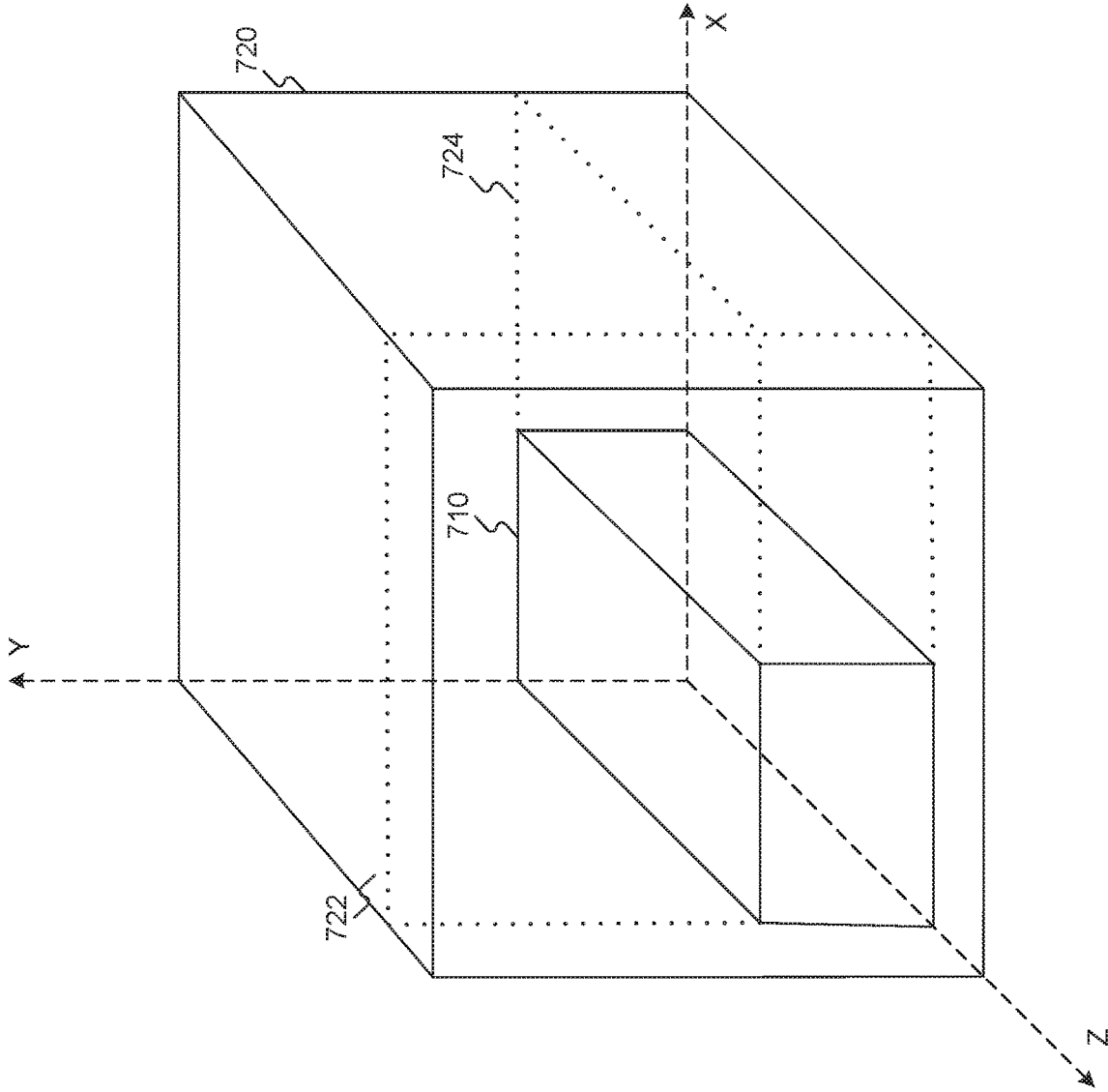


FIG. 7

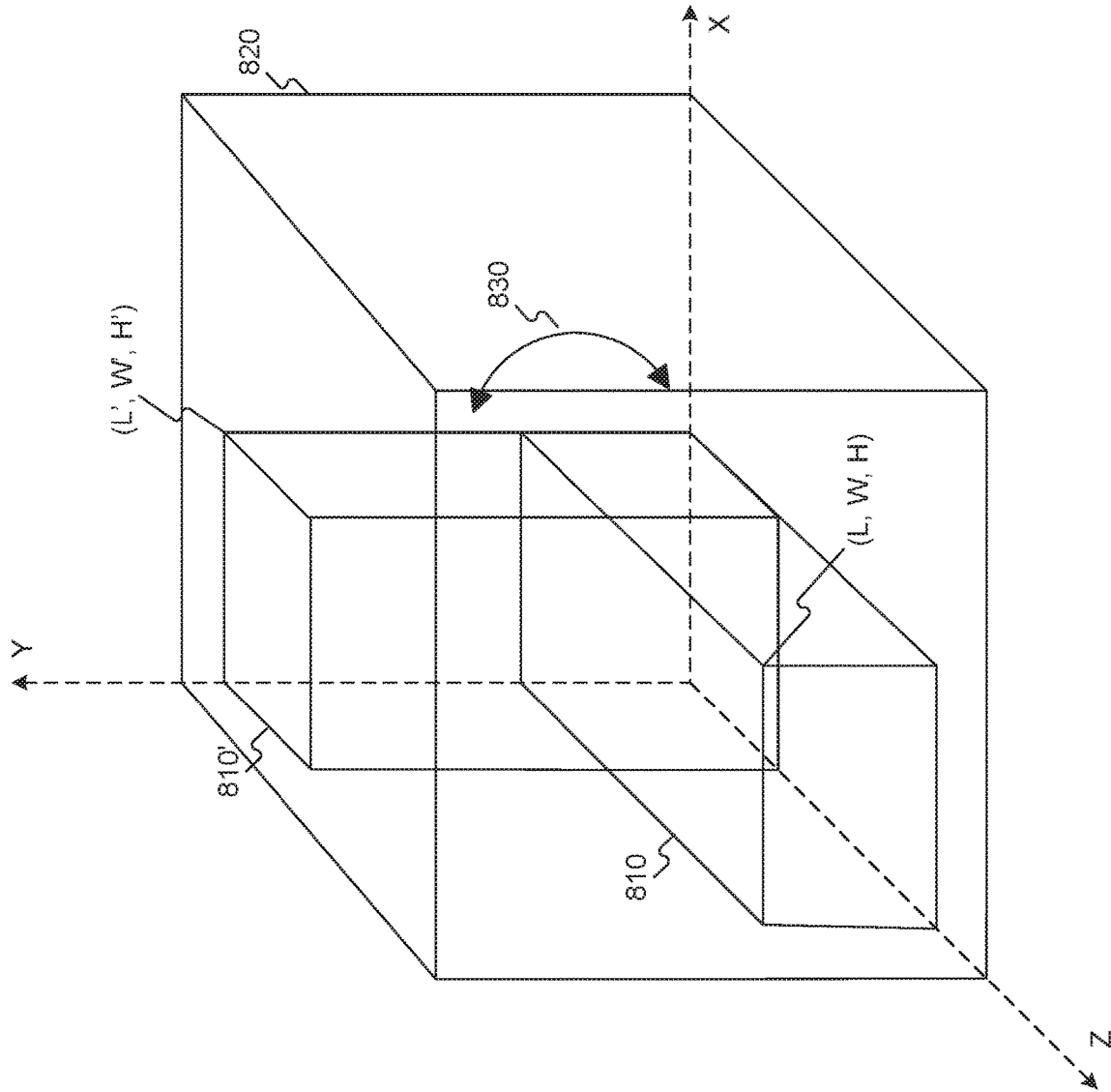


FIG. 8

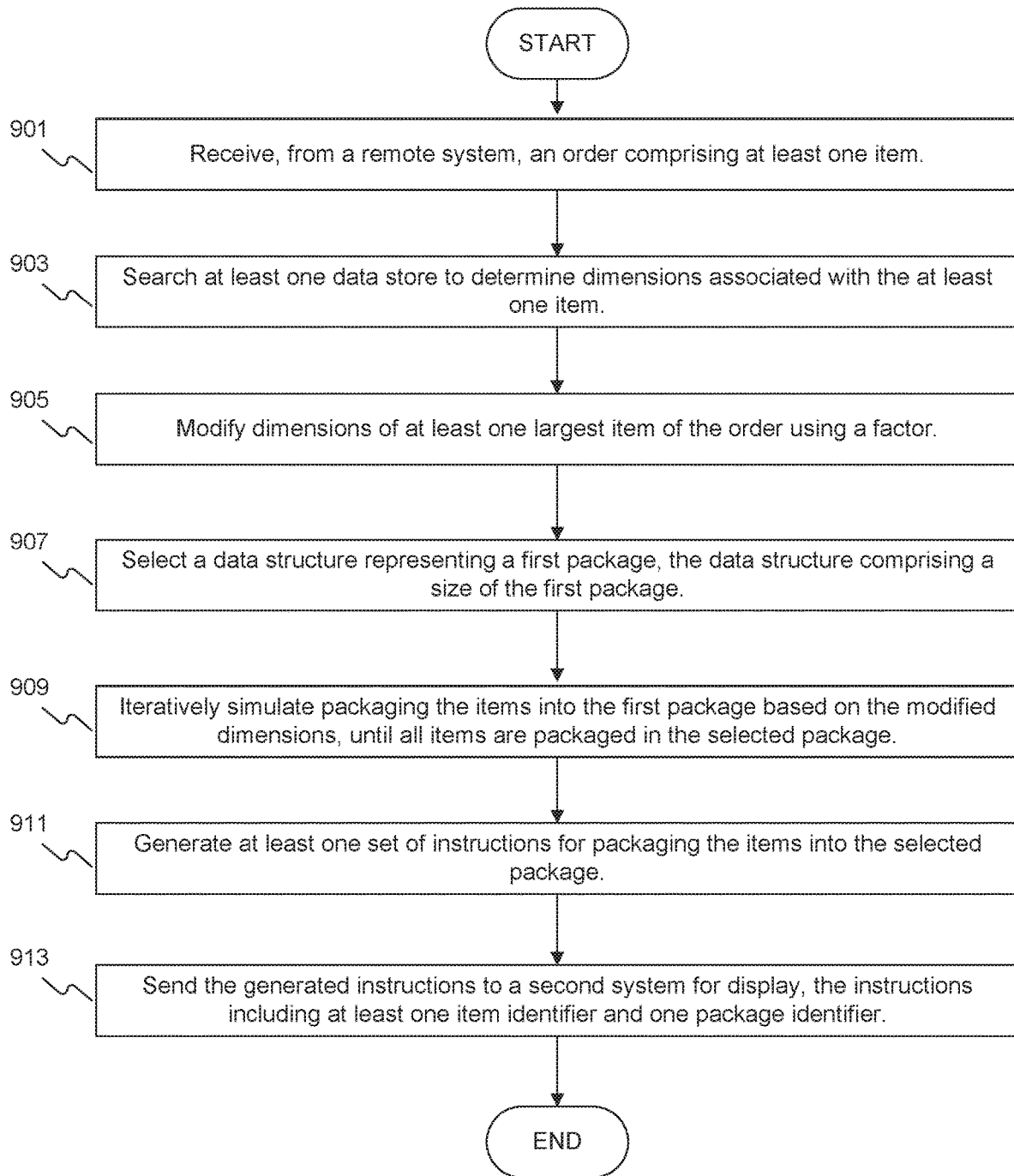


FIG. 9

## SYSTEMS AND METHODS FOR EFFICIENT BOX PACKING AND VISUALIZATION

### CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of and claims the benefit of priority to U.S. application Ser. No. 16/580,069, filed Sep. 24, 2019, the contents of which are hereby incorporated herein by reference.

### TECHNICAL FIELD

The present disclosure generally relates to computerized systems and methods for efficient box packing and visualization. In particular, embodiments of the present disclosure relate to inventive and unconventional systems for automatically determining a packing sequence and layout based on the items to be packed and the fragileness of those items.

### BACKGROUND

Consumers often purchase multiple products online in a single order for delivery. Due to the fragileness of some items and cost constraints, special packing arrangements may be required for a consumer's order. For example, some items may be fragile and require packing bubbles for protection during transit. Additionally, some consumers may prefer to save on costs by having fewer boxes used in their delivery.

Existing computerized methods for packing, however, are inefficient. They rely on rough estimates that do not account for packing more fragile items. For example, existing methods for packing do not incorporate room for packing bubble when providing rough estimates of the packing arrangement. Additionally, existing computerized methods do not provide visualizations of the optimal placement of items in a box, inefficiently leaving the choice up to the packer. These inefficiencies in packing may result in costly orders for consumers (e.g., due to more boxes being used for delivery than are necessary).

Therefore, there is a need for improved methods and systems for computerized systems and methods for efficient box packing and visualization.

### SUMMARY

One aspect of the present disclosure is directed to a computerized system for automatic packing determination. The system may comprise at least one processor; and at least one non transitory storage medium comprising instructions that, when executed by the at least one processor, cause the at least one processor to perform steps. The steps may comprise receiving, from a remote system, an order comprising at least one item; searching at least one data store to determine dimensions associated with the at least one item; and modifying dimensions of at least one largest item of the order using a factor. The steps may further comprise selecting a data structure representing a first package, the data structure comprising a size of the first package; iteratively simulating packing the items into the first package based on the modified dimensions, until all items are packed in the selected package; and generating at least one set of instructions for packing the items into the selected package. The steps may further comprise sending the generated instructions to a second system for display, the instructions including at least one item identifier and one package identifier.

Yet another aspect of the present disclosure is directed to a method for generating packing instructions. The method may comprise receiving, from a remote system, an order comprising at least one item; searching at least one data store to determine dimensions associated with the at least one item; and modifying dimensions of at least one largest item of the order using a factor. The method may further comprise selecting a data structure representing a first package, the data structure comprising a size of the first package; iteratively simulating packing the items into the first package based on the modified dimensions, until all items are packed in the selected package; and generating at least one set of instructions for packing the items into the selected package. The method may further comprise sending the generated instructions to a second system for display, the instructions including at least one item identifier and one package identifier.

Yet another aspect of the present disclosure is directed to a computerized system for automatic packing determination. The system may comprise at least one processor; and at least one non transitory storage medium comprising instructions that, when executed by the at least one processor, cause the at least one processor to perform steps. The steps may comprise receiving, from a remote system, an order comprising at least one item; searching at least one data store to determine dimensions associated with the at least one item; and modifying dimensions of at least one largest item of the order using a factor. The steps may further comprise selecting a data structure representing a first package, the data structure comprising a size of the first package; iteratively simulating packing the items into the first package based on the modified dimensions, until all items are packed in the selected package; and generating at least one set of instructions for packing the items into the selected package. The steps may further comprise sending the generated instructions to a second system for display, the instructions including at least one item identifier and one package identifier; wherein the generated instructions include instructions for placement of each item to be packed and an order of placement for each item to be packed; and a computer-generated image depicting each item to be packed.

Other systems, methods, and computer-readable media are also discussed herein.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a schematic block diagram illustrating an exemplary embodiment of a network comprising computerized systems for communications enabling shipping, transportation, and logistics operations, consistent with the disclosed embodiments.

FIG. 1B depicts a sample Search Result Page (SRP) that includes one or more search results satisfying a search request along with interactive user interface elements, consistent with the disclosed embodiments.

FIG. 1C depicts a sample Single Display Page (SDP) that includes a product and information about the product along with interactive user interface elements, consistent with the disclosed embodiments.

FIG. 1D depicts a sample Cart page that includes items in a virtual shopping cart along with interactive user interface elements, consistent with the disclosed embodiments.

FIG. 1E depicts a sample Order page that includes items from the virtual shopping cart along with information regarding purchase and shipping, along with interactive user interface elements, consistent with the disclosed embodiments.

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FIG. 2 is a diagrammatic illustration of an exemplary fulfillment center configured to utilize disclosed computerized systems, consistent with the disclosed embodiments.

FIG. 3 is a schematic block diagram illustrating an exemplary embodiment of a network comprising computerized systems for efficient box packing and visualization, consistent with the disclosed embodiments.

FIG. 4 depicts an exemplary visualization of an item in a packing box, consistent with the disclosed embodiments.

FIG. 5 depicts an exemplary visualization of an item in a packing box, consistent with the disclosed embodiments.

FIG. 6 depicts an exemplary visualization of an item in a packing box, consistent with the disclosed embodiments.

FIG. 7 depicts an exemplary visualization of an item in a packing box, consistent with the disclosed embodiments.

FIG. 8 depicts an exemplary visualization of an item rotated in a packing box, consistent with the disclosed embodiments.

FIG. 9 depicts a process for generating instructions for efficient box packing, consistent with the disclosed embodiments.

#### DETAILED DESCRIPTION

The following detailed description refers to the accompanying drawings. Wherever possible, the same reference numbers are used in the drawings and the following description to refer to the same or similar parts. While several illustrative embodiments are described herein, modifications, adaptations and other implementations are possible. For example, substitutions, additions, or modifications may be made to the components and steps illustrated in the drawings, and the illustrative methods described herein may be modified by substituting, reordering, removing, or adding steps to the disclosed methods. Accordingly, the following detailed description is not limited to the disclosed embodiments and examples. Instead, the proper scope of the invention is defined by the appended claims.

Embodiments of the present disclosure are directed to systems and methods configured for efficient box packing and visualization. The disclosed embodiments are advantageously capable of generating instructions and visualizations of those instructions using product information of items in an order placed by a customer and package information for packing boxes. Product information associated with the items and package information for packing boxes may be retrieved from one or more databases. For example, product information may include dimensions such as length, height, width, volume, weight, product identifier, or fragileness of the associated item. Package information for packing boxes may include dimensions such as length, height, width, volume, weight, or package identifier of the packing box.

In one implementation, a packing system may determine the largest item of each order based on the determined dimensions retrieved from a database. For example, the largest item may be determined by sorting the items by longest length or by largest volume. The fragileness of an item may be indicated by a “normal” tag or a “fragile” tag, which is used to modify the volume of the largest item such that packing bubble may be accounted for in determining the most efficient box packing. The packing system may generate instructions of the most efficient box packing by iteratively calculating the remaining spaces within the package and determining the best arrangement of each item based on the item’s size. The generated instructions may use

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a customer’s selection of one of a smaller number of packages used for delivery, lower cost, or higher fill rate in generating the instructions.

In some embodiments, the packing system may send the generated instructions to a visualization system via a network. The visualization system may display the most efficient box packing arrangements according to the instructions received from the packing system. For example, the visualization system may simultaneously display the text of the received instructions and an animated tutorial on how to package the items according to the instructions. The animated tutorial may comprise computer-generated images of the package and each item to be packed, including rotations and placement of the items into the package.

Referring to FIG. 1A, a schematic block diagram 100 illustrating an exemplary embodiment of a system comprising computerized systems for communications enabling shipping, transportation, and logistics operations is shown. As illustrated in FIG. 1A, system 100 may include a variety of systems, each of which may be connected to one another via one or more networks. The systems may also be connected to one another via a direct connection, for example, using a cable. The depicted systems include a shipment authority technology (SAT) system 101, an external front end system 103, an internal front end system 105, a transportation system 107, mobile devices 107A, 107B, and 107C, seller portal 109, shipment and order tracking (SOT) system 111, fulfillment optimization (FO) system 113, fulfillment messaging gateway (FMG) 115, supply chain management (SCM) system 117, warehouse management system 119, mobile devices 119A, 119B, and 119C (depicted as being inside of fulfillment center (FC) 200), 3<sup>rd</sup> party fulfillment systems 121A, 121B, and 121C, fulfillment center authorization system (FC Auth) 123, and labor management system (LMS) 125.

SAT system 101, in some embodiments, may be implemented as a computer system that monitors order status and delivery status. For example, SAT system 101 may determine whether an order is past its Promised Delivery Date (PDD) and may take appropriate action, including initiating a new order, reshipping the items in the non-delivered order, canceling the non-delivered order, initiating contact with the ordering customer, or the like. SAT system 101 may also monitor other data, including output (such as a number of packages shipped during a particular time period) and input (such as the number of empty cardboard boxes received for use in shipping). SAT system 101 may also act as a gateway between different devices in system 100, enabling communication (e.g., using store-and-forward or other techniques) between devices such as external front end system 103 and FO system 113.

External front end system 103, in some embodiments, may be implemented as a computer system that enables external users to interact with one or more systems in system 100. For example, in embodiments where system 100 enables the presentation of systems to enable users to place an order for an item, external front end system 103 may be implemented as a web server that receives search requests, presents item pages, and solicits payment information. For example, external front end system 103 may be implemented as a computer or computers running software such as the Apache HTTP Server, Microsoft Internet Information Services (IIS) NGINX, or the like. In other embodiments, external front end system 103 may run custom web server software designed to receive and process requests from external devices (e.g., mobile device 102A or computer 102B), acquire information from databases and other data

stores based on those requests, and provide responses to the received requests based on acquired information.

In some embodiments, external front end system **103** may include one or more of a web caching system, a database, a search system, or a payment system. In one aspect, external front end system **103** may comprise one or more of these systems, while in another aspect, external front end system **103** may comprise interfaces (e.g., server-to-server, database-to-database, or other network connections) connected to one or more of these systems.

An illustrative set of steps, illustrated by FIGS. **1B**, **1C**, **1D**, and **1E**, will help to describe some operations of external front end system **103**. External front end system **103** may receive information from systems or devices in system **100** for presentation and/or display. For example, external front end system **103** may host or provide one or more web pages, including a Search Result Page (SRP) (e.g., FIG. **1B**), a Single Detail Page (SDP) (e.g., FIG. **1C**), a Cart page (e.g., FIG. **1D**), or an Order page (e.g., FIG. **1E**). A user device (e.g., using mobile device **102A** or computer **102B**) may navigate to external front end system **103** and request a search by entering information into a search box. External front end system **103** may request information from one or more systems in system **100**. For example, external front end system **103** may request information from FO System **113** that satisfies the search request. External front end system **103** may also request and receive (from FO System **113**) a Promised Delivery Date or “PDD” for each product included in the search results. The PDD, in some embodiments, may represent an estimate of when a package containing the product will arrive at the user’s desired location or a date by which the product is promised to be delivered at the user’s desired location if ordered within a particular period of time, for example, by the end of the day (11:59 PM). (PDD is discussed further below with respect to FO System **113**.)

External front end system **103** may prepare an SRP (e.g., FIG. **1B**) based on the information. The SRP may include information that satisfies the search request. For example, this may include pictures of products that satisfy the search request. The SRP may also include respective prices for each product, or information relating to enhanced delivery options for each product, PDD, weight, size, offers, discounts, or the like. External front end system **103** may send the SRP to the requesting user device (e.g., via a network).

A user device may then select a product from the SRP, e.g., by clicking or tapping a user interface, or using another input device, to select a product represented on the SRP. The user device may formulate a request for information on the selected product and send it to external front end system **103**. In response, external front end system **103** may request information related to the selected product. For example, the information may include additional information beyond that presented for a product on the respective SRP. This could include, for example, shelf life, country of origin, weight, size, number of items in package, handling instructions, or other information about the product. The information could also include recommendations for similar products (based on, for example, big data and/or machine learning analysis of customers who bought this product and at least one other product), answers to frequently asked questions, reviews from customers, manufacturer information, pictures, or the like.

External front end system **103** may prepare an SDP (Single Detail Page) (e.g., FIG. **1C**) based on the received product information. The SDP may also include other interactive elements such as a “Buy Now” button, a “Add to Cart” button, a quantity field, a picture of the item, or the

like. The SDP may further include a list of sellers that offer the product. The list may be ordered based on the price each seller offers such that the seller that offers to sell the product at the lowest price may be listed at the top. The list may also be ordered based on the seller ranking such that the highest ranked seller may be listed at the top. The seller ranking may be formulated based on multiple factors, including, for example, the seller’s past track record of meeting a promised PDD. External front end system **103** may deliver the SDP to the requesting user device (e.g., via a network).

The requesting user device may receive the SDP which lists the product information. Upon receiving the SDP, the user device may then interact with the SDP. For example, a user of the requesting user device may click or otherwise interact with a “Place in Cart” button on the SDP. This adds the product to a shopping cart associated with the user. The user device may transmit this request to add the product to the shopping cart to external front end system **103**.

External front end system **103** may generate a Cart page (e.g., FIG. **1D**). The Cart page, in some embodiments, lists the products that the user has added to a virtual “shopping cart.” A user device may request the Cart page by clicking on or otherwise interacting with an icon on the SRP, SDP, or other pages. The Cart page may, in some embodiments, list all products that the user has added to the shopping cart, as well as information about the products in the cart such as a quantity of each product, a price for each product per item, a price for each product based on an associated quantity, information regarding PDD, a delivery method, a shipping cost, user interface elements for modifying the products in the shopping cart (e.g., deletion or modification of a quantity), options for ordering other product or setting up periodic delivery of products, options for setting up interest payments, user interface elements for proceeding to purchase, or the like. A user at a user device may click on or otherwise interact with a user interface element (e.g., a button that reads “Buy Now”) to initiate the purchase of the product in the shopping cart. Upon doing so, the user device may transmit this request to initiate the purchase to external front end system **103**.

External front end system **103** may generate an Order page (e.g., FIG. **1E**) in response to receiving the request to initiate a purchase. The Order page, in some embodiments, re-lists the items from the shopping cart and requests input of payment and shipping information. For example, the Order page may include a section requesting information about the purchaser of the items in the shopping cart (e.g., name, address, e-mail address, phone number), information about the recipient (e.g., name, address, phone number, delivery information), shipping information (e.g., speed/method of delivery and/or pickup), payment information (e.g., credit card, bank transfer, check, stored credit), user interface elements to request a cash receipt (e.g., for tax purposes), or the like. External front end system **103** may send the Order page to the user device.

The user device may enter information on the Order page and click or otherwise interact with a user interface element that sends the information to external front end system **103**. From there, external front end system **103** may send the information to different systems in system **100** to enable the creation and processing of a new order with the products in the shopping cart.

In some embodiments, external front end system **103** may be further configured to enable sellers to transmit and receive information relating to orders.

Internal front end system **105**, in some embodiments, may be implemented as a computer system that enables internal

users (e.g., employees of an organization that owns, operates, or leases system **100**) to interact with one or more systems in system **100**. For example, in embodiments where network **101** enables the presentation of systems to enable users to place an order for an item, internal front end system **105** may be implemented as a web server that enables internal users to view diagnostic and statistical information about orders, modify item information, or review statistics relating to orders. For example, internal front end system **105** may be implemented as a computer or computers running software such as the Apache HTTP Server, Microsoft Internet Information Services (IIS), NGINX, or the like. In other embodiments, internal front end system **105** may run custom web server software designed to receive and process requests from systems or devices depicted in system **100** (as well as other devices not depicted), acquire information from databases and other data stores based on those requests, and provide responses to the received requests based on acquired information.

In some embodiments, internal front end system **105** may include one or more of a web caching system, a database, a search system, a payment system, an analytics system, an order monitoring system, or the like. In one aspect, internal front end system **105** may comprise one or more of these systems, while in another aspect, internal front end system **105** may comprise interfaces (e.g., server-to-server, database-to-database, or other network connections) connected to one or more of these systems.

Transportation system **107**, in some embodiments, may be implemented as a computer system that enables communication between systems or devices in system **100** and mobile devices **107A-107C**. Transportation system **107**, in some embodiments, may receive information from one or more mobile devices **107A-107C** (e.g., mobile phones, smart phones, PDAs, or the like). For example, in some embodiments, mobile devices **107A-107C** may comprise devices operated by delivery workers. The delivery workers, who may be permanent, temporary, or shift employees, may utilize mobile devices **107A-107C** to effect delivery of packages containing the products ordered by users. For example, to deliver a package, the delivery worker may receive a notification on a mobile device indicating which package to deliver and where to deliver it. Upon arriving at the delivery location, the delivery worker may locate the package (e.g., in the back of a truck or in a crate of packages), scan or otherwise capture data associated with an identifier on the package (e.g., a barcode, an image, a text string, an RFID tag, or the like) using the mobile device, and deliver the package (e.g., by leaving it at a front door, leaving it with a security guard, handing it to the recipient, or the like). In some embodiments, the delivery worker may capture photo(s) of the package and/or may obtain a signature using the mobile device. The mobile device may send information to transportation system **107** including information about the delivery, including, for example, time, date, GPS location, photo(s), an identifier associated with the delivery worker, an identifier associated with the mobile device, or the like. Transportation system **107** may store this information in a database (not pictured) for access by other systems in system **100**. Transportation system **107** may, in some embodiments, use this information to prepare and send tracking data to other systems indicating the location of a particular package.

In some embodiments, certain users may use one kind of mobile device (e.g., permanent workers may use a specialized PDA with custom hardware such as a barcode scanner, stylus, and other devices) while other users may use other

kinds of mobile devices (e.g., temporary or shift workers may utilize off-the-shelf mobile phones and/or smart-phones).

In some embodiments, transportation system **107** may associate a user with each device. For example, transportation system **107** may store an association between a user (represented by, e.g., a user identifier, an employee identifier, or a phone number) and a mobile device (represented by, e.g., an International Mobile Equipment Identity (IMEI), an International Mobile Subscription Identifier (IMSI), a phone number, a Universal Unique Identifier (UUID), or a Globally Unique Identifier (GUID)). Transportation system **107** may use this association in conjunction with data received on deliveries to analyze data stored in the database in order to determine, among other things, a location of the worker, an efficiency of the worker, or a speed of the worker.

Seller portal **109**, in some embodiments, may be implemented as a computer system that enables sellers or other external entities to electronically communicate with one or more systems in system **100**. For example, a seller may utilize a computer system (not pictured) to upload or provide product information, order information, contact information, or the like, for products that the seller wishes to sell through system **100** using seller portal **109**.

Shipment and order tracking system **111**, in some embodiments, may be implemented as a computer system that receives, stores, and forwards information regarding the location of packages containing products ordered by customers (e.g., by a user using devices **102A-102B**). In some embodiments, shipment and order tracking system **111** may request or store information from web servers (not pictured) operated by shipping companies that deliver packages containing products ordered by customers.

In some embodiments, shipment and order tracking system **111** may request and store information from systems depicted in system **100**. For example, shipment and order tracking system **111** may request information from transportation system **107**. As discussed above, transportation system **107** may receive information from one or more mobile devices **107A-107C** (e.g., mobile phones, smart phones, PDAs, or the like) that are associated with one or more of a user (e.g., a delivery worker) or a vehicle (e.g., a delivery truck). In some embodiments, shipment and order tracking system **111** may also request information from warehouse management system (WMS) **119** to determine the location of individual products inside of a fulfillment center (e.g., fulfillment center **200**). Shipment and order tracking system **111** may request data from one or more of transportation system **107** or WMS **119**, process it, and present it to a device (e.g., user devices **102A** and **102B**) upon request.

Fulfillment optimization (FO) system **113**, in some embodiments, may be implemented as a computer system that stores information for customer orders from other systems (e.g., external front end system **103** and/or shipment and order tracking system **111**). FO system **113** may also store information describing where particular items are held or stored. For example, certain items may be stored only in one fulfillment center, while certain other items may be stored in multiple fulfillment centers. In still other embodiments, certain fulfillment centers may be designed to store only a particular set of items (e.g., fresh produce or frozen products). FO system **113** stores this information as well as associated information (e.g., quantity, size, date of receipt, expiration date, etc.).

FO system **113** may also calculate a corresponding PDD (promised delivery date) for each product. The PDD, in some embodiments, may be based on one or more factors.

For example, FO system **113** may calculate a PDD for a product based on a past demand for a product (e.g., how many times that product was ordered during a period of time), an expected demand for a product (e.g., how many customers are forecast to order the product during an upcoming period of time), a network-wide past demand indicating how many products were ordered during a period of time, a network-wide expected demand indicating how many products are expected to be ordered during an upcoming period of time, one or more counts of the product stored in each fulfillment center **200**, which fulfillment center stores each product, expected or current orders for that product, or the like.

In some embodiments, FO system **113** may determine a PDD for each product on a periodic basis (e.g., hourly) and store it in a database for retrieval or sending to other systems (e.g., external front end system **103**, SAT system **101**, shipment and order tracking system **111**). In other embodiments, FO system **113** may receive electronic requests from one or more systems (e.g., external front end system **103** SAT system **101**, shipment and order tracking system **111**) and calculate the PDD on demand.

Fulfillment messaging gateway (FMG) **115**, in some embodiments, may be implemented as a computer system that receives a request or response in one format or protocol from one or more systems in system **100**, such as FO system **113**, converts it to another format or protocol, and forward it in the converted format or protocol to other systems, such as WMS **119** or 3<sup>rd</sup> party fulfillment systems **121A**, **121B**, or **121C**, and vice versa.

Supply chain management (SCM) system **117**, in some embodiments, may be implemented as a computer system that performs forecasting functions. For example, SCM system **117** may forecast a level of demand for a particular product based on, for example, based on a past demand for products, an expected demand for a product, a network-wide past demand, a network-wide expected demand, a count products stored in each fulfillment center **200**, expected or current orders for each product, or the like. In response to this forecasted level and the amount of each product across all fulfillment centers, SCM system **117** may generate one or more purchase orders to purchase and stock a sufficient quantity to satisfy the forecasted demand for a particular product.

Warehouse management system (WMS) **119**, in some embodiments, may be implemented as a computer system that monitors workflow. For example, WMS **119** may receive event data from individual devices (e.g., devices **107A-107C** or **119A-119C**) indicating discrete events. For example, WMS **119** may receive event data indicating the use of one of these devices to scan a package. As discussed below with respect to fulfillment center **200** and FIG. 2, during the fulfillment process, a package identifier (e.g., a barcode or RFID tag data) may be scanned or read by machines at particular stages (e.g., automated or handheld barcode scanners, RFID readers, high-speed cameras, devices such as tablet **119A**, mobile device/PDA **119B**, computer **119C**, or the like). WMS **119** may store each event indicating a scan or a read of a package identifier in a corresponding database (not pictured) along with the package identifier, a time, date, location, user identifier, or other information, and may provide this information to other systems (e.g., shipment and order tracking system **111**).

WMS **119**, in some embodiments, may store information associating one or more devices (e.g., devices **107A-107C** or **119A-119C**) with one or more users associated with system **100**. For example, in some situations, a user (such as a part-

or full-time employee) may be associated with a mobile device in that the user owns the mobile device (e.g., the mobile device is a smartphone). In other situations, a user may be associated with a mobile device in that the user is temporarily in custody of the mobile device (e.g., the user checked the mobile device out at the start of the day, will use it during the day, and will return it at the end of the day).

WMS **119**, in some embodiments, may maintain a work log for each user associated with system **100**. For example, WMS **119** may store information associated with each employee, including any assigned processes (e.g., unloading trucks, picking items from a pick zone, rebin wall work, packing items), a user identifier, a location (e.g., a floor or zone in a fulfillment center **200**), a number of units moved through the system by the employee (e.g., number of items picked, number of items packed), an identifier associated with a device (e.g., devices **119A-119C**), or the like. In some embodiments, WMS **119** may receive check-in and check-out information from a timekeeping system, such as a timekeeping system operated on a device **119A-119C**.

3<sup>rd</sup> party fulfillment (3PL) systems **121A-121C**, in some embodiments, represent computer systems associated with third-party providers of logistics and products. For example, while some products are stored in fulfillment center **200** (as discussed below with respect to FIG. 2), other products may be stored off-site, may be produced on demand, or may be otherwise unavailable for storage in fulfillment center **200**. 3PL systems **121A-121C** may be configured to receive orders from FO system **113** (e.g., through FMG **115**) and may provide products and/or services (e.g., delivery or installation) to customers directly. In some embodiments, one or more of 3PL systems **121A-121C** may be part of system **100**, while in other embodiments, one or more of 3PL systems **121A-121C** may be outside of system **100** (e.g., owned or operated by a third-party provider).

Fulfillment Center Auth system (FC Auth) **123**, in some embodiments, may be implemented as a computer system with a variety of functions. For example, in some embodiments, FC Auth **123** may act as a single-sign on (SSO) service for one or more other systems in system **100**. For example, FC Auth **123** may enable a user to log in via internal front end system **105**, determine that the user has similar privileges to access resources at shipment and order tracking system **111**, and enable the user to access those privileges without requiring a second log in process. FC Auth **123**, in other embodiments, may enable users (e.g., employees) to associate themselves with a particular task. For example, some employees may not have an electronic device (such as devices **119A-119C**) and may instead move from task to task, and zone to zone, within a fulfillment center **200**, during the course of a day. FC Auth **123** may be configured to enable those employees to indicate what task they are performing and what zone they are in at different times of day.

Labor management system (LMS) **125**, in some embodiments, may be implemented as a computer system that stores attendance and overtime information for employees (including full-time and part-time employees). For example, LMS **125** may receive information from FC Auth **123**, WMA **119**, devices **119A-119C**, transportation system **107**, and/or devices **107A-107C**.

The particular configuration depicted in FIG. 1A is an example only. For example, while FIG. 1A depicts FC Auth system **123** connected to FO system **113**, not all embodiments require this particular configuration. Indeed, in some embodiments, the systems in system **100** may be connected to one another through one or more public or private

networks, including the Internet, an Intranet, a WAN (Wide-Area Network), a MAN (Metropolitan-Area Network), a wireless network compliant with the IEEE 802.11a/b/g/n Standards, a leased line, or the like. In some embodiments, one or more of the systems in system **100** may be implemented as one or more virtual servers implemented at a data center, server farm, or the like.

FIG. 2 depicts a fulfillment center **200**. Fulfillment center **200** is an example of a physical location that stores items for shipping to customers when ordered. Fulfillment center (FC) **200** may be divided into multiple zones, each of which are depicted in FIG. 2. These “zones,” in some embodiments, may be thought of as virtual divisions between different stages of a process of receiving items, storing the items, retrieving the items, and shipping the items. So while the “zones” are depicted in FIG. 2, other divisions of zones are possible, and the zones in FIG. 2 may be omitted, duplicated, or modified in some embodiments.

Inbound zone **203** represents an area of FC **200** where items are received from sellers who wish to sell products using system **100** from FIG. 1A. For example, a seller may deliver items **202A** and **202B** using truck **201**. Item **202A** may represent a single item large enough to occupy its own shipping pallet, while item **202B** may represent a set of items that are stacked together on the same pallet to save space.

A worker will receive the items in inbound zone **203** and may optionally check the items for damage and correctness using a computer system (not pictured). For example, the worker may use a computer system to compare the quantity of items **202A** and **202B** to an ordered quantity of items. If the quantity does not match, that worker may refuse one or more of items **202A** or **202B**. If the quantity does match, the worker may move those items (using, e.g., a dolly, a handtruck, a forklift, or manually) to buffer zone **205**. Buffer zone **205** may be a temporary storage area for items that are not currently needed in the picking zone, for example, because there is a high enough quantity of that item in the picking zone to satisfy forecasted demand. In some embodiments, forklifts **206** operate to move items around buffer zone **205** and between inbound zone **203** and drop zone **207**. If there is a need for items **202A** or **202B** in the picking zone (e.g., because of forecasted demand), a forklift may move items **202A** or **202B** to drop zone **207**.

Drop zone **207** may be an area of FC **200** that stores items before they are moved to picking zone **209**. A worker assigned to the picking task (a “picker”) may approach items **202A** and **202B** in the picking zone, scan a barcode for the picking zone, and scan barcodes associated with items **202A** and **202B** using a mobile device (e.g., device **119B**). The picker may then take the item to picking zone **209** (e.g., by placing it on a cart or carrying it).

Picking zone **209** may be an area of FC **200** where items **208** are stored on storage units **210**. In some embodiments, storage units **210** may comprise one or more of physical shelving, bookshelves, boxes, totes, refrigerators, freezers, cold stores, or the like. In some embodiments, picking zone **209** may be organized into multiple floors. In some embodiments, workers or machines may move items into picking zone **209** in multiple ways, including, for example, a forklift, an elevator, a conveyor belt, a cart, a handtruck, a dolly, an automated robot or device, or manually. For example, a picker may place items **202A** and **202B** on a handtruck or cart in drop zone **207** and walk items **202A** and **202B** to picking zone **209**.

A picker may receive an instruction to place (or “stow”) the items in particular spots in picking zone **209**, such as a

particular space on a storage unit **210**. For example, a picker may scan item **202A** using a mobile device (e.g., device **119B**). The device may indicate where the picker should stow item **202A**, for example, using a system that indicate an aisle, shelf, and location. The device may then prompt the picker to scan a barcode at that location before stowing item **202A** in that location. The device may send (e.g., via a wireless network) data to a computer system such as WMS **119** in FIG. 1A indicating that item **202A** has been stowed at the location by the user using device **119B**.

Once a user places an order, a picker may receive an instruction on device **119B** to retrieve one or more items **208** from storage unit **210**. The picker may retrieve item **208**, scan a barcode on item **208**, and place it on transport mechanism **214**. While transport mechanism **214** is represented as a slide, in some embodiments, transport mechanism may be implemented as one or more of a conveyor belt, an elevator, a cart, a forklift, a handtruck, a dolly, a cart, or the like. Item **208** may then arrive at packing zone **211**.

Packing zone **211** may be an area of FC **200** where items are received from picking zone **209** and packed into boxes or bags for eventual shipping to customers. In packing zone **211**, a worker assigned to receiving items (a “rebin worker”) will receive item **208** from picking zone **209** and determine what order it corresponds to. For example, the rebin worker may use a device, such as computer **1190**, to scan a barcode on item **208**. Computer **1190** may indicate visually which order item **208** is associated with. This may include, for example, a space or “cell” on a wall **216** that corresponds to an order. Once the order is complete (e.g., because the cell contains all items for the order), the rebin worker may indicate to a packing worker (or “packer”) that the order is complete. The packer may retrieve the items from the cell and place them in a box or bag for shipping. The packer may then send the box or bag to a hub zone **213**, e.g., via forklift, cart, dolly, handtruck, conveyor belt, manually, or otherwise.

Hub zone **213** may be an area of FC **200** that receives all boxes or bags (“packages”) from packing zone **211**. Workers and/or machines in hub zone **213** may retrieve package **218** and determine which portion of a delivery area each package is intended to go to, and route the package to an appropriate camp zone **215**. For example, if the delivery area has two smaller sub-areas, packages will go to one of two camp zones **215**. In some embodiments, a worker or machine may scan a package (e.g., using one of devices **119A-119C**) to determine its eventual destination. Routing the package to camp zone **215** may comprise, for example, determining a portion of a geographical area that the package is destined for (e.g., based on a postal code) and determining a camp zone **215** associated with the portion of the geographical area.

Camp zone **215**, in some embodiments, may comprise one or more buildings, one or more physical spaces, or one or more areas, where packages are received from hub zone **213** for sorting into routes and/or sub-routes. In some embodiments, camp zone **215** is physically separate from FC **200** while in other embodiments camp zone **215** may form a part of FC **200**.

Workers and/or machines in camp zone **215** may determine which route and/or sub-route a package **220** should be associated with, for example, based on a comparison of the destination to an existing route and/or sub-route, a calculation of workload for each route and/or sub-route, the time of day, a shipping method, the cost to ship the package **220**, a PDD associated with the items in package **220**, or the like. In some embodiments, a worker or machine may scan a package (e.g., using one of devices **119A-119C**) to deter-

mine its eventual destination. Once package **220** is assigned to a particular route and/or sub-route, a worker and/or machine may move package **220** to be shipped. In exemplary FIG. 2, camp zone **215** includes a truck **222**, a car **226**, and delivery workers **224A** and **224B**. In some embodiments, truck **222** may be driven by delivery worker **224A**, where delivery worker **224A** is a full-time employee that delivers packages for FC **200** and truck **222** is owned, leased, or operated by the same company that owns, leases, or operates FC **200**. In some embodiments, car **226** may be driven by delivery worker **224B**, where delivery worker **224B** is a “flex” or occasional worker that is delivering on an as-needed basis (e.g., seasonally). Car **226** may be owned, leased, or operated by delivery worker **224B**.

Referring to FIG. 3, a schematic block diagram illustrating an exemplary embodiment of a network comprising computerized systems for efficient box packing and visualization is shown. As illustrated in FIG. 3, system **100** may include a packing system **310** that may communicate with a visualization system **320** via a network **330**. Additionally, system **100** may include all components and processes as explained above for FIG. 1. In some embodiments, packing system **310** and visualization system **320** may communicate with other components of system **100** via network **330** or via a direct connection, for example using a cable. While in FIG. 3, packing system **310** and visualization system **320** are depicted as separate systems, in some embodiments, packing system **310** and visualization system **320** may be implemented as a single device or system.

As shown in FIG. 3, packing system **310** may comprise a processor **312**, a memory **314**, and a database **316**. Processor **312** may be one or more known processing devices, such as a microprocessor from the Pentium™ family manufactured by Intel™ or the Turion™ family manufactured by AMD™. Processor **312** may constitute a single core or multiple core processor that executes parallel processes simultaneously. For example, processor **312** may use logical processors to simultaneously execute and control multiple processes. Processor **312** may implement virtual machine technologies or other known technologies to provide the ability to execute, control, run, manipulate, store, etc. multiple software processes, applications, programs, etc. In another example, processor **312** may include a multiple-core processor arrangement configured to provide parallel processing functionalities to allow packing system **310** to execute multiple processes simultaneously. One of ordinary skill in the art would understand that other types of processor arrangements could be implemented that provide for the capabilities disclosed herein.

Memory **314** may store one or more operating systems that perform known operating system functions when executed by processor **312**. By way of example, the operating system may include Microsoft Windows, Unix, Linux, Android, Mac OS, iOS, or other types of operating systems. Accordingly, examples of the disclosed invention may operate and function with computer systems running any type of operating system. Memory **314** may be a volatile or non-volatile, magnetic, semiconductor, tape, optical, removable, non-removable, or other type of storage device or tangible computer readable medium.

Database **316** may include, for example, Oracle™ databases, Sybase™ databases, or other relational databases or non-relational databases, such as Hadoop™ sequence files, HBase™, or Cassandra™. Database **316** may include computing components (e.g., database management system, database server, etc.) configured to receive and process requests for data stored in memory devices of the

database(s) and to provide data from the database(s). Database **316** may include NoSQL databases such as HBase, MongoDB™ or Cassandra™. Alternatively, database **316** may include relational databases such as Oracle, MySQL and Microsoft SQL Server. In some embodiments, database **316** may take the form of servers, general purpose computers, mainframe computers, or any combination of these components.

Database **316** may store data that may be used by processor **312** for performing methods and processes associated with disclosed examples. Database **316** may be located in packing system **310** as shown in FIG. 3, or alternatively, it may be in an external storage device located outside of packing system **310**. Data stored in **316** may include any suitable data associated with packing boxes (e.g., data structures of different available packing boxes, package identifier, etc.).

Packing system **310**, in some embodiments, may be implemented as a computer system that generates instructions for efficient box packing using the product information of items in an order and package information for packing boxes. Packing system **310** may comprise a single computer or may be configured as a distributed computer system including multiple computers that interoperate to perform one or more of the processes and functionalities associated with the disclosed examples. In some embodiments, packing system **310** may receive a customer’s order comprising at least one item from a remote system (e.g., external front end system **103**).

Packing system **310** may search at least one data store (e.g., a database of FO system **113**) to determine dimensions associated with each item of the order. For example, FO system **113** may store information (e.g., length, volume, weight, fragileness, product identifier, etc.) associated with each item. Packing system **310** may then retrieve the information associated with each item from FO system **113** via network **330**. Packing system **310** may determine the largest item of each order based on the determined dimensions retrieved from FO system **113**. The largest item may be determined by sorting the items of the orders by longest length or by largest volume (i.e., the mathematical product of length, width, and height of the item).

The product information retrieved from FO system **113** may include a tag associated with each item. The tag associated with each item indicates a degree of fragileness for that item and, accordingly, the amount of packing bubble needed to package that item. For example, a pillow may be tagged as “normal,” which indicates a fragileness factor of 1.1 while a glass cup may be tagged as “fragile,” which indicates a fragileness factor of 1.3. (Other factors are possible; these factors are intended only as exemplary values.) A “normal” tag indicates that the associated item requires less room in the package for packing bubble and a “fragile” tag indicates that the associated item requires more room in the package for packing bubble. Packing system **310** may modify dimensions of at least one largest item of the order using a tag associated with the at least one largest item. For example, packing system **10** may multiply each of the length, width, and height of the item by the fragileness factor for that item, resulting in a modified item. Upon receiving the order and retrieving the product information for each item of the order, packing system **310** may select a data structure representing a packing box (“package”) from database **316**, where the data structure comprises a size (i.e., length, width, height, volume) of the package. Packing system **310** may select the data structure based on the dimensions and tag associated with each item of the order.

That is, the data structure may be selected so that at least one item fits in the data structure.

Packing system **310** may simulate packing the modified largest item into a package and calculate a plurality of remaining spaces in the package by subtracting the dimensions of the modified largest item from the dimensions of the package. Simulation of packing the modified largest item may include repeatedly modifying the first orientation of the item (i.e., rotating the item) until the optimal orientation of the item is determined. For example, packing system **310** may rotate the item in six different directions (i.e., orient the rectangular prism-shaped item in the direction of each of its six faces) until it fits in the package and is positioned in the corner of the package adjacent to the length of the package. Packing system **310** may store the orientation data for each rotation of the item in database **316**. The orientation data may include the coordinate point of each of the eight corners of the item after each rotation. Packing system **310** may instantiate at least one data structure corresponding to the calculated remaining spaces in the package, where each data structure comprises a size of an associated calculated remaining space. Packing system **310** may instantiate data structures of various combinations of the calculated remaining spaces to determine the most efficient packing arrangement of the items in the package. For example, the remaining spaces may be represented by two larger rectangular prisms or by three smaller rectangular prisms depending on how the remaining spaces are divided. Packing system **310** may determine the center point in a three-dimensional system (e.g., 0,0,0 within an X, Y, Z coordinate system in a data structure) for each data structure corresponding to the calculated remaining spaces in the package in order to determine the optimal packing arrangement for each item. For example, packing system **310** may determine the center point of each space after each iteration.

Packing system **310** may iteratively simulate packing the remaining items from the order into the remaining spaces of the package based on the size of the remaining items modified by their respective fragileness factors. Packing system **310** may simulate all possible combinations of packing (e.g., sequence of items placed in package, iteratively sorting the items from longest to shortest length, iteratively sorting the items from largest to smallest volume, etc.) and store each possible combination in database **316**. The iterative simulation may include rotating and storing the orientation data of each item, as explained above. Packing system **310** may choose a larger package if, at any iteration, an item does not fit in the selected package. Packing system **310** may iteratively simulate packing each item of the order until all items are packed in the package.

Packing system **310** may choose the most efficient box packing arrangement based on the various calculated combinations and generate at least one set of instructions for packing the items into the selected package. For example, packing system **10** may generate a first list of package arrangements for packing the items by largest volume and a second list of package arrangements for packing the items by largest side (i.e., longest single dimension). Packing system **310** may select one of the first list or the second list and generate the instructions for packing based on the selected list.

Packing system **310** may select the list for instruction generation based on a customer's selection of one of a smaller number of packages used for delivery, a lower cost, or a higher fill rate (i.e., highest percentage of each package being filled). Packing system **310** may send the generated

instructions to visualization system **320** for display, where the instructions include at least one item identifier and one package identifier.

As shown in FIG. 3, visualization system **320** may comprise a processor **322**, a memory **324**, a database **326**, and a device **328**. Similar to processor **312** described above, processor **322** may be one or more known processing devices, such as a microprocessor from the Pentium™ family manufactured by Intel™ or the Turion™ family manufactured by AMD™. Processor **322** may constitute a single core or multiple core processor that executes parallel processes simultaneously. For example, processor **322** may use logical processors to simultaneously execute and control multiple processes. Processor **322** may implement virtual machine technologies or other known technologies to provide the ability to execute, control, run, manipulate, store, etc. multiple software processes, applications, programs, etc. In another example, processor **322** may include a multiple-core processor arrangement configured to provide parallel processing functionalities to allow visualization system **320** to execute multiple processes simultaneously. One of ordinary skill in the art would understand that other types of processor arrangements could be implemented that provide for the capabilities disclosed herein.

Similar to memory **314** described above, memory **324** may store one or more operating systems that perform known operating system functions when executed by processor **322**. By way of example, the operating system may include Microsoft Windows, Unix, Linux, Android, Mac OS, iOS, or other types of operating systems. Accordingly, examples of the disclosed invention may operate and function with computer systems running any type of operating system. Memory **324** may be a volatile or non-volatile, magnetic, semiconductor, tape, optical, removable, non-removable, or other type of storage device or tangible computer readable medium.

Similar to database **316** described above, database **326** may include, for example, Oracle™ databases, Sybase™ databases, or other relational databases or non-relational databases, such as Hadoop™ sequence files, HBase™, or Cassandra™. Database **326** may include computing components (e.g., database management system, database server, etc.) configured to receive and process requests for data stored in memory devices of the database(s) and to provide data from the database(s). Database **316** may include NoSQL databases such as HBase, MongoDB™ or Cassandra™. Alternatively, database **326** may include relational databases such as Oracle, MySQL and Microsoft SQL Server. In some embodiments, database **326** may take the form of servers, general purpose computers, mainframe computers, or any combination of these components.

Database **326** may store data that may be used by processor **322** for performing methods and processes associated with disclosed examples. Database **326** may be located in visualization system **320** as shown in FIG. 3, or alternatively, it may be in an external storage device located outside of packing system **320**. Data stored in **316** may include any suitable data associated with packing boxes (e.g., data received from packing system **310**, visual displays of previous packing arrangements and instructions, etc.).

Device **328** may be a tablet, mobile device, computer, or the like. Device **328** may include a display. The display may include, for example, liquid crystal displays (LCD), light emitting diode screens (LED), organic light emitting diode screens (OLED), a touch screen, and other known display devices. The display may show various information to a user. For example, it may display visual packing arrange-

ments according to the generated instructions provided by packing system 310. Device 328 may include one or more input/output (I/O) devices (i.e., a user interface). The I/O devices may include one or more devices that allow device 328 to send and receive information from another device. The I/O devices may also include one or more communication modules (not shown) for sending and receiving information from visualization system 320 by, for example, establishing wired or wireless connectivity between device 328 and network 330.

Visualization system 320, in some embodiments, may be implemented as a computer system that displays packing arrangements according to instructions for efficient box packing received from packing system 310. Visualization system 320 may comprise a single computer or may be configured as a distributed computer system including multiple computers that interoperate to perform one or more of the processes and functionalities associated with the disclosed examples. In some embodiments, visualization system may simultaneously display the instructions received from packing system 310 and an animated tutorial according to the received instructions on device 328. The instructions may include instructions for placement of each item to be packed, an order of placement (i.e., sequence) for each item to be packed, or a computer-generated image depicting each item to be packed. For example, device 328 may display text of the instructions. In another example, device 328 may display a rectangular prism that represents the package and a smaller rectangular prism that represents an item. Device 328 may further display the rectangular prism representing the item rotating in different directions before settling into the position within the package associated with the received instructions.

Referring to FIG. 4, an exemplary visualization of an item in a packing box is shown. As illustrated in FIG. 4, visualization system 320 may display on device 328 a modified item 410 in a package 420 in a three-dimensional coordinate system (i.e., X, Y, Z). Modified item 410 may represent a largest item in an order, including an associated fragileness factor to account for the packing bubble.

Referring to FIG. 5, an exemplary visualization of an item in a packing box is shown. As illustrated in FIG. 5, visualization system 320 may display on device 328 a modified item 510 in a package 520 in a three-dimensional coordinate system (i.e., X, Y, Z), similar to FIG. 4 as explained above. Modified item 510 may represent a largest item in an order, including an associated fragileness factor to account for the packing bubble. FIG. 5 also includes dividers 522 and 524, which demonstrate the calculated remaining space as rectangular prisms. Dividers 522 and 524 are depicted for illustrative purposes and are not necessarily intended to represent physical structures. For example, dividers 522 and 524 show three remaining spaces in FIG. 5. A center point 526 of one of the remaining spaces is depicted as a point (a, b, c). Although the center point of each remaining space is not shown, the center point may be determined for each remaining space in all of the disclosed embodiments herein.

Referring to FIG. 6, an exemplary visualization of an item in a packing box is shown. As illustrated in FIG. 6, visualization system 320 may display on device 328 a modified item 610 in a package 620 in a three-dimensional coordinate system (i.e., X, Y, Z), similar to FIGS. 4 and 5 as explained above. Modified item 610 may represent a largest item in an order, including an associated fragileness factor to account for the packing bubble. FIG. 6 also includes dividers 622 and 624, which demonstrate the calculated remaining space as rectangular prisms. Dividers 622 and 624 are depicted for

illustrative purposes and are not, in all embodiments, implemented as physical structures. For example, FIG. 6 shows three remaining spaces having sizes different from those of FIG. 5.

Referring to FIG. 7, an exemplary visualization of an item in a packing box is shown. As illustrated in FIG. 7, visualization system 320 may display on device 328 a modified item 710 in a package 720 in a three-dimensional coordinate system (i.e., X, Y, Z), similar to FIGS. 4-6 as explained above. Modified item 710 may represent a largest item in an order, including an associated fragileness factor to account for the packing bubble. FIG. 7 also includes dividers 722 and 724, which demonstrate the calculated remaining space as rectangular prisms. Dividers 722 and 724 are depicted for illustrative purposes and are not, in all embodiments, implemented as physical structures. For example, FIG. 7 shows three remaining spaces having sizes different from those of FIG. 5 or 6.

Referring to FIG. 8, an exemplary visualization of an item rotated in a packing box is shown. As illustrated in FIG. 8, a visualization system 320 may display on device 328 a modified item 810 in a package 820 in a three-dimensional coordinate system (i.e., X, Y, Z), similar to FIGS. 4-7 as explained above. Modified item 810 may represent a largest item in an order, including an associated fragileness factor to account for the packing bubble. Packing system 310 may store the orientation data for each modified item 810, including the orientation data for modified item 810 after each rotation. The orientation data may include the coordinate point of each of the eight corners of modified item 810. Although a coordinate point (L, W, H) of modified item 810 is depicted for one corner of modified item 810, it is noted that a coordinate point of each of the eight corners of modified item 810 is recorded to determine the optimal orientation of modified item 810 within package 820. Although a rotated modified item 810' is depicted in one direction (i.e., one face) of modified item 810, it is noted that modified item 810 may be rotated in each of six directions. Similarly, a coordinate point (L', W', H') of rotated modified item 810' is depicted for one corner of rotated modified item 810', but a coordinate point of each of the eight corners of rotated modified item 810' is recorded to determine the optimal orientation of modified item 810 within package 820.

Referring to FIG. 9, a process 900 for generating instructions for efficient box packing is shown.

In step 901, packing system 310 receives, from a remote system (e.g., external front end system 100), an order comprising at least one item. The order may be submitted to the remote system by a customer and the remote system may assign an order identifier to the submitted order.

In step 903, packing system 310 receives the order identifier and searches at least one data store (e.g., FO system 113) for product information associated with the at least one item of the order to determine dimensions associated with the at least one item of the order. The product information may include a tag of each item and the dimensions of each item. The tag associated with each item may indicate a degree of fragileness for that item which, in some embodiments, represents the amount of packing bubbles, or other packing material, extra space, or the like needed to package that item. The dimensions associated with each item may include the height, width, length, or weight of each item.

In step 905, packing system 310 modifies the dimensions of at least one largest item of the order using a factor. Packing system 310 may determine the largest item by

sorting the items of the order by largest volume or longest length. The factor may be a fragileness factor to account for the amount of packing bubble to be used in the package. An item tagged as "normal" may have a fragileness factor of 1.1 whereas an item tagged as "fragile" may have a fragileness factor of 1.3. The dimensions of at least one largest item may be modified by multiplying the volume of the item by its associated fragileness factor.

In step 907, packing system 310 selects a data structure representing a first package. Packing system 310 may select a data structure representing a package from database 316 based on the dimensions and tag associated with each item of the order. That is, the data structure may be selected so that at least one item fits in the data structure and so that the customer's selection of one of a smaller number of packages, a lower cost, or a higher fill rate is met. The data structure may include a size (e.g., length, width, height, volume, etc.) of the first package.

In step 909, packing system 310 may iteratively simulate packing the items into the first package based on the modified dimensions until all items are packed in the selected package. The iterative simulation may include calculating a plurality of remaining spaces in the package by subtracting the dimensions of the modified largest item from the dimensions of the package. Packing system 310 may iteratively simulate packing the remaining items from the order into the remaining spaces of the package based on the size of the remaining items modified by their respective fragileness factors. Simulation of packing the modified largest item may include repeatedly modifying the first orientation of the item until the optimal orientation of the item is determined. For example, packing system 310 may rotate the item in six different directions until it fits in the package and is positioned in the corner of the package adjacent to the length of the package. Packing system 310 may store the orientation data for each rotation of the item in database 316. The orientation data may include the coordinate point of each of the eight corners of the item after each rotation. Packing system 310 may instantiate at least one data structure corresponding to the calculated remaining spaces in the package, where each data structure comprises a size of an associated calculated remaining space. Packing system 310 may instantiate data structures of various combinations of the calculated remaining spaces to determine the most efficient packing arrangement of the items in the package. For example, the remaining spaces may be represented by two larger rectangular prisms or by three smaller rectangular prisms depending on how the remaining spaces are divided. Packing system 310 may determine the center point in a three-dimensional system (e.g., 0,0,0 within an X, Y, Z coordinate system in a data structure) for each data structure corresponding to the calculated remaining spaces in the package in order to determine the optimal packing arrangement for each item. For example, packing system 310 may determine the center point of each space after each iteration.

Packing system 310 may iteratively simulate packing the remaining items from the order into the remaining spaces of the package based on the size of the remaining items modified by their respective fragileness factors. Packing system 310 may simulate all possible combinations of packing (e.g., sequence of items placed in package, iteratively sorting the items from longest to shortest length, iteratively sorting the items from largest to smallest volume, etc.) and store each possible combination in database 316. The iterative simulation may include rotating and storing the orientation data of each item, as explained above. Packing

system 310 may choose a larger package if, at any iteration, an item does not fit in the selected package. Packing system 310 may iteratively simulate packing each item of the order until all items are packed in the package.

In step 911, packing system 310 generates at least one set of instructions for packing the items into the selected package. The instructions may include the most efficient box packing arrangement and order of item placement into the package. The instructions may be generated based on the customer's selection of one of a smaller number of packages used for delivery, a lower cost, or a higher fill rate. For example, packing system 310 may generate a first list of package arrangements for packing the items by largest volume and a second list of package arrangements for packing the items by largest side. Packing system 310 may select one of the first list or the second list and generate the instructions for packing based on the selected list.

Packing system 310 may select the list for instruction generation based on a customer's selection of one of a smaller number of packages used for delivery, a lower cost, or a higher fill rate (i.e., highest percentage of each package being filled).

In step 913, packing system 310 sends the generated instructions to visualization system 320 for display, where the instructions include at least one item identifier and one package identifier. Visualization system 320 may display packing arrangements and order of item placement based on the instructions received from packing system 310. Visualization system may simultaneously display the instructions and an animated tutorial according to the received instructions.

While the present disclosure has been shown and described with reference to particular embodiments thereof, it will be understood that the present disclosure can be practiced, without modification, in other environments. The foregoing description has been presented for purposes of illustration. It is not exhaustive and is not limited to the precise forms or embodiments disclosed. Modifications and adaptations be apparent to those skilled in the art from consideration of the specification and practice of the disclosed embodiments. Additionally, although aspects of the disclosed embodiments are described as being stored in memory, one skilled in the art will appreciate that these aspects can also be stored on other types of computer readable media, such as secondary storage devices, for example, hard disks or CD ROM, or other forms of RAM or ROM, USB media, DVD, Blu-ray, or other optical drive media.

Computer programs based on the written description and disclosed methods are within the skill of an experienced developer. Various programs or program modules can be created using any of the techniques known to one skilled in the art or can be designed in connection with existing software. For example, program sections or program modules can be designed in or by means of .Net Framework, .Net Compact Framework (and related languages, such as Visual Basic, C, etc.), Java, C++, Objective-C, HTML, HTML/AJAX combinations, XML, or HTML with included Java applets.

Moreover, while illustrative embodiments have been described herein, the scope of any and all embodiments having equivalent elements, modifications, omissions, combinations (e.g., of aspects across various embodiments), adaptations and/or alterations as would be appreciated by those skilled in the art based on the present disclosure. The limitations in the claims are to be interpreted broadly based on the language employed in the claims and not limited to

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examples described in the present specification or during the prosecution of the application. The examples are to be construed as non-exclusive. Furthermore, the steps of the disclosed methods may be modified in any manner, including by reordering steps and/or inserting or deleting steps. It is intended, therefore, that the specification and examples be considered as illustrative only, with a true scope and spirit being indicated by the following claims and their full scope of equivalents.

What is claimed is:

1. A computerized system for automatic packing determination, comprising:
  - at least one processor; and
  - at least one non-transitory storage medium comprising instructions that, when executed by the at least one processor, cause the at least one processor to perform steps comprising:
    - receiving, from a remote system, an order comprising a plurality of items;
    - searching at least one data store to determine a first tag associated with the plurality of items;
    - wherein each first tag is associated with a fragileness factor that is determined based on a dimension of the plurality of items;
    - modifying dimensions of at least one item of the order using the fragileness factor;
    - selecting a data structure representing a first package, the data structure comprising a size of the first package;
    - iteratively simulating packing the items into the first package based on the modified dimensions, wherein simulating packing the items into the first package comprises:
      - repeatedly modifying an orientation of a first item of the plurality of items;
      - calculating a plurality of remaining spaces in the first package for each orientation of the first item; and
      - instantiating a data structure corresponding to the calculated remaining spaces in the first package to determine an optimal packing arrangement of a second item in the first package;
    - generating at least one set of instructions for packing the items into the first package based on the iterative simulation; and
    - sending the generated instructions to a second system for display, wherein the generated instructions are configured to cause the second system to display instructions for placement of the plurality of items to be packed on a user interface.
2. The system of claim 1, wherein iteratively simulating packing further comprises:
  - determining dimensions of the plurality of items of the order;
  - determining a largest item of the plurality of items in the order based on the determined dimensions;
  - simulating packing the largest item into the first package;
  - calculating a plurality of remaining spaces in the first package by subtracting the dimensions of the largest item from the dimensions of the first package; and
  - iteratively simulating packing at least one remaining item into at least one of the calculated remaining spaces.
3. The system of claim 2, wherein iteratively simulating packing further comprises:
  - selecting a first largest-volume item by determining an item with the largest volume;
  - iteratively simulating packing the first largest-volume item into a package;

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- selecting a next largest-volume item by determining an item with the second largest volume;
  - repeatedly simulating packing the next largest-volume item into the package until all items are packed;
  - generating a first list of packages for packing by largest volume;
  - selecting a first largest-side item by determining an item with a longest single dimension;
  - iteratively simulating packing the first largest-side item into a package;
  - selecting a next largest-side item by determining an item with a second-longest single dimension;
  - repeatedly simulating packing the next largest-side item into the package until all items are packed; and
  - generating a second list of packages for packing by largest volume; and
- wherein generating the at least one set of instructions comprises:
- selecting one of the first list or the second list; and
  - generating the instructions based on the selected list.
4. The system of claim 3, wherein selecting one of the first list or the second list comprises selecting a list requiring:
    - a smaller number of packages,
    - a lower cost, or
    - a higher fill rate.
  5. The system of claim 1, wherein iteratively simulating packing the largest item into the first package further comprises:
    - determining dimensions of the plurality of items of the order;
    - determining the largest item of the plurality of items in the order based on the determined dimensions;
    - simulating packing the plurality of items into the first package using a first orientation for the plurality of items;
    - determining a fill rate for the first package based on packing the plurality of items into the first package using the first orientation;
    - repeatedly modifying the first orientation for the plurality of items and determining a fill rate for the first package by simulating packing the plurality of items using at least one modified first orientation; and
    - selecting a set of orientations for the plurality of items based on maximization of fill rate.
  6. The system of claim 1, wherein:
    - the dimension of the plurality of items is one of a length, volume, or weight of the plurality of items.
  7. The system of claim 1, wherein:
    - the fragileness factor is selected from one of normal or fragile; and
    - a value of the normal fragileness factor is smaller than a value of the fragile fragileness factor.
  8. The system of claim 1, wherein if the simulating determines that the at least one item does not fit into the selected package:
    - choosing a larger package, and
    - iteratively simulating packing the plurality of items until all items are packed in the larger package.
  9. The system of claim 1, wherein the generated instructions are configured to cause the second system to display information on a user interface and further comprise:
    - an order of placement for the plurality of items to be packed; or
    - a computer-generated image depicting the plurality of items to be packed.
  10. A method for generating packing instructions, comprising:

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receiving, from a remote system, an order comprising a plurality of items;  
 searching at least one data store to determine a first tag associated with the plurality of items;  
 wherein each first tag is associated with a fragileness factor that is determined based on a dimension of the plurality of items;  
 modifying dimensions of at least one item of the order using the fragileness factor;  
 selecting a data structure representing a first package, the data structure comprising a size of the first package;  
 iteratively simulating packing the items into the first package based on the modified dimensions, wherein simulating packing the items into the first package comprises:  
 repeatedly modifying an orientation of a first item of the plurality of items;  
 calculating a plurality of remaining spaces in the first package for each orientation of the first item; and  
 instantiating a data structure corresponding to the calculated remaining spaces in the first package to determine an optimal packing arrangement of a second item in the first package;  
 generating at least one set of instructions for packing the items into the first package based on the iterative simulation; and  
 sending the generated instructions to a second system for display, wherein the generated instructions are configured to cause the second system to display instructions for placement of the plurality of items to be packed on a user interface.

**11.** The method of claim **10**, wherein iteratively simulating packing further comprises:  
 determining dimensions of the plurality of items of the order;  
 determining a largest item of the plurality of items in the order based on the determined dimensions;  
 simulating packing the largest item into the first package;  
 calculating a plurality of remaining spaces in the first package by subtracting the dimensions of the largest item from the dimensions of the first package; and  
 iteratively simulating packing at least one remaining item into at least one of the calculated remaining spaces.

**12.** The method of claim **11**, wherein iteratively simulating packing further comprises:  
 selecting a first largest-volume item by determining an item with the largest volume;  
 iteratively simulating packing the first largest-volume item into a package;  
 selecting a next largest-volume item by determining an item with the second largest volume;  
 repeatedly simulating packing the next largest-volume item into the package until all items are packed; and  
 generating a first list of packages for packing by largest volume;  
 selecting a first largest-side item by determining an item with a longest single dimension;  
 iteratively simulating packing the first largest-side item into a package;  
 selecting a next largest-side item by determining an item with a second-longest single dimension;  
 repeatedly simulating packing the next largest-side item into the package until all items are packed; and  
 generating a second list of packages for packing by largest volume; and  
 wherein generating the at least one set of instructions comprises:

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selecting one of the first list or the second list; and  
 generating the instructions based on the selected list.

**13.** The method of claim **12**, wherein selecting one of the first list or the second list comprises selecting a list requiring:  
 a smaller number of packages,  
 a lower cost, or  
 a higher fill rate.

**14.** The method of claim **10**, wherein iteratively simulating packing the largest item into the first package further comprises:  
 determining dimensions of the plurality of items of the order;  
 determining a largest item of the plurality of items in the order based on the determined dimensions;  
 simulating packing the plurality of items into the first package using a first orientation for the plurality of items;  
 determining a fill rate for the first package based on packing the plurality of items into the first package using the first orientation;  
 repeatedly modifying the first orientation for the plurality of items and determining a fill rate for the first package by simulating packing the plurality of items using at least one modified first orientation; and  
 selecting a set of orientations for the items based on maximization of fill rate.

**15.** The method of claim **10**, wherein:  
 the dimension of the plurality of items is one of a length, volume, or weight of the plurality of items.

**16.** The method of claim **10**, wherein: modifying dimensions of an item using the factor further comprises:  
 the fragileness factor is selected from one of normal or fragile; and  
 a value of the normal fragileness factor is smaller than a value of the fragile fragileness factor.

**17.** The method of claim **10**, wherein if the simulating determines that the at least one item does not fit into the selected package:  
 choosing a larger package, and  
 iteratively simulating packing the plurality of items until all items are packed in the larger package.

**18.** The method of claim **10**, wherein the generated instructions are configured to cause the second system to display information on a user interface and further comprise:  
 an order of placement for the plurality of items to be packed; or  
 a computer-generated image depicting the plurality of items to be packed.

**19.** A computerized system for automatic packing determination, comprising:  
 at least one processor; and  
 at least one non-transitory storage medium comprising instructions that, when executed by the at least one processor, cause the at least one processor to perform steps comprising:  
 receiving, from a remote system, an order comprising a plurality of items;  
 searching at least one data store to determine a first tag associated with the plurality of items, wherein each first tag is associated with a fragileness factor that is determined based on a dimension of the plurality of items;  
 modifying dimensions of at least one item of the order using the fragileness factor;

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selecting a data structure representing a first package,  
 the data structure comprising a size of the first  
 package;  
 iteratively simulating packing the items into the first  
 package based on the modified dimensions, wherein  
 5 simulating packing the items into the first package  
 comprises:  
 repeatedly modifying an orientation of a first item of  
 the plurality of items;  
 10 calculating a plurality of remaining spaces in the first  
 package for each orientation of the first item; and  
 instantiating a data structure corresponding to the  
 calculated remaining spaces in the first package to  
 determine an optimal packing arrangement of a  
 15 second item in the first package;  
 generating at least one set of instructions for packing  
 the items into the selected package;  
 sending the generated instructions to a second system  
 for display, wherein the generated instructions are

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configured to cause the second system to display  
 instructions for placement of the plurality of items to  
 be packed on a user interface;  
 wherein the generated instructions include:  
 instructions for placement of the plurality of items to  
 be packed;  
 an order of placement for the plurality of items to be  
 packed; and  
 a computer-generated image depicting the plurality  
 of items to be packed.  
**20.** The system of claim **19**, wherein iteratively simulating  
 packing further comprises:  
 simulating packing a largest item into the first package;  
 calculating a plurality of remaining spaces in the first  
 package by subtracting the dimensions of the largest  
 item from the dimensions of the first package; and  
 iteratively simulating packing at least one remaining item  
 into at least one of the calculated remaining spaces.

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